THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

VOL. 59 Thursday, December 15, 1938 No. 1165

PUBLISHED WEEKLY

Subscription Terms : 17s. 6d. per annum.
Foreign and Colonial : 20s. per annum.
All Subscriptions are payable in advance.

All Communications to be addressed to the Editor, the Advertisement Manager, or the Publisher of

THE FOUNDRY TRADE JOURNAL
49, WELLINGTON STREET, LONDON, W.C.2

Telegraphic Address : "Zacatecas, Rand, London."
Telephone : Temple Bar 3951 (5 lines).

THE FOUNDRY TRADE JOURNAL IS THE OFFICIAL ORGAN OF

The Institute of British Foundrymen

The Institute of Vitreous Enamellers

The Welsh Engineers' and Founders' Association

and

The Foundry Trades' Equipment and Supplies Association

Institute of British Foundrymen

PRESIDENT : 1938-39

J. Hepworth, J.P., M.P., "Ingle Nook," Bolton Road, Bradford.

LIST OF SECRETARIES—

General Secretary : T. Makemson, Saint John Street Chambers, Deansgate, Manchester, 3. London Office : 49, Wellington Street, London, W.C.2.

Birmingham, Coventry and West Midlands : A. A. Timmins, A.I.C., 21-23, St. Paul's Square, Birmingham, 3.

East Midlands : B. Gale, "Parkdale," Boulton Lane, Alvaston, Derby.

Lancashire : J. E. Cooke, 7, Warren Drive, Swinton, Manchester.

London : G. W. Duglish, Stewarts & Lloyds, Limited, Winchester House, Old Broad Street, E.C.2

Middlesbrough : G. P. Kirk, North-Eastern Iron Refining Company, Limited, Stillington, Stockton-on-Tees.

Newcastle-upon-Tyne : C. Lashly, Sir W. G. Armstrong, Whitworth & Company (Ironfounders), Limited, Close Works, Gateshead-on-Tyne.

Scottish : J. Bell, 60, St. Enoch Square, Glasgow.

Sheffield : T. R. Walker, M.A., "The Priory," Oughtibridge, near Sheffield.

Wales and Monmouth : J. J. McClelland, 12, Clifton Place, Newport, Mon.

West Riding of Yorkshire : S. W. Wise, 110, Pullan Avenue, Eccleshill, Bradford.

South Africa : F. C. Williams, Magor House (Fifth Floor), 74, Fox Street, Johannesburg.

Bristol : A. Hares, Park Crescent, 648, Stapleton Road, Bristol, 5.

Burnley : W. Haworth, 37, Westbourne Avenue, Burnley, Lancs.

East Anglian : J. L. Francis, 12, Glenhurst Avenue, Colchester Road, Ipswich.

Falkirk : T. R. Goodwin, "Viewfield," Falkirk Road, Bonnybridge, Scotland.

Lincoln : E. R. Walter, M.Sc., The Technical College, Lincoln.

The Institute of Vitreous Enamellers

President : Sir Harold Hartley, F.R.S., Euston Station, London, W.C.1.

Chairman : W. H. Whittle, W. H. Whittle, Limited, Eccles, near Manchester.

Hon. Secretary : Miss E. Christine Elliot, 49, Wellington Street, Strand, London, W.C.2.

Foundry Trades' Equipment and Supplies Association

President : A. C. Turner, Russell House, Adelphi, London, W.C.2.

Secretary : K. W. Bridges, Grand Buildings, Trafalgar Square, London, W.C.2.

Welsh Engineers' and Founders' Association

President : W. E. Clement, Morfa Foundry, New Dock, Llanelly.

Secretary : J. D. D. Davis, 9, Royal Metal Exchange, Swansea.

BRITISH CAST IRON RESEARCH ASSOCIATION

The Registered Office and Laboratories of the B.C.I.R.A. are :—
21-23, ST. PAUL'S SQUARE, BIRMINGHAM
Telephone : Colmore 4274-4275 *Telegrams : CIRA*
The B.C.I.R.A. Scottish Laboratories are :—
Foundry Technical Institute, Meek's Road, Falkirk
Telephone : 332

Contents

	PAGE
The Square Deal	439
British Ironfounders' Association	440
Random Shots	440
Making a Large Lathe Bed	441
Electric Furnace Practice in the United States	445
High-Duty Cast Iron	447
Use of Electric Welding Plant in the Steel Foundry	448
Publication Received	450
The Powder Metallurgy of Iron	451
Imported Electric-Furnace Pig-Iron	452
The Late Mr. E. Ronceray	452
National Institute of Industrial Psychology	452
The Week's News in Brief	454
Trade Talk	454
Personal	454
Obituary	454
Contracts Open	454
Company Reports	454
New Companies	454
Forthcoming Events	454
Raw Material Markets	456

The Square Deal

This slogan launched by the railway companies is not of the happiest type, as it tends to drive people into two camps and introduce arguments not germane to the subject. We do not like slogans, which nowadays are not battle-cries, but catch phrases designed to focus attention on a phase of activity, which is not necessarily the essential one. If, however, a slogan is deemed necessary, then "Help us to remove the shackles" appeals to us to be preferable, because a study of the claims put forward by the railway companies shows them to be centred around archaic legislation. Railway charges rest on the supposition of monopoly and the rates imposed are designed to prevent the abuse of this non-existent state of affairs. Years of tiresome and expensive legislation have brought into being sixty-six classifications set out in a four-hundred page book. The result is that every time a new material is evolved, there is a search as to which is the cheapest classification. For instance, the first electric steel ingots that were made were duly despatched as "undamageable Bessemer." The nomenclature might have been at fault, but it was a commonsense compromise! Since the inception of the railways, about a hundred years ago, road transport has become of ever-increasing importance, for it possesses the advantage of involving a minimum of handling from factory to consumer. Where sidings exist at both ends of a journey, then, generally speaking, the railways have retained their business. Coal from the pit to the power station is typical of this condition. Even the manufacturer of lorries uses the railway services, just as one finds electric motors in a modern gasworks. This statement indicates that the railways are an essential in the life of any community, and, as such, they should be accorded an opportunity for putting their "house in order." As individuals, we inherently object to the remnants of the D.O.R.A. still existing, and we can well imagine the concern of the more progressive leaders of thought in railway circles at having to run their business under archaic regulations. Suppose a firm lent to an organisation for a series of tests some sand, a portable moulding machine, some testing apparatus, pig, scrap and coke—all of which could go into a 10-ton wagon. Unless some broadminded official broke the rules, the consignment would probably have to be dealt with in five or six classifications, and the waste of time would be such that the sender would hire a lorry rather than submit to what he would term red tape. Under present regulations mixed consignments form a complication which prevents legitimate competition. Road transport is equally essential to the foundry industry, and if, as a result of the efforts made by the railway companies, each type of goods is carried by the most economical means, then the nation as a whole will benefit. Fear is expressed that the railway companies might use extra freedom for increasing rates in directions where they still possess a monopoly. With a very minimum of exceptions we fail to see where this monopoly can exist, for to-day one knows of 140-ton castings, pig-iron and propellers all being despatched by road. If the real demand of the railway companies is confined to repealing Acts of Parliament which limit the general freedom of the railway companies to conduct their business on modern lines, there can surely be little objection to granting it. The return of some of the heavy traffic to the railways would relieve annoying congestion on the main roads and, by allowing the main lines to work at a figure nearer to capacity, would permit of reduced carriage rates. If this be not the solution, then the only alternative is to pull up the rails, and convert the area so exposed into a gigantic system of *autobahnen*. This would mean more reliance being placed upon petrol, the closing down of coal pits, decrease in personal safety, destruction of capital and problematic progress. Even the most ardent supporter of the motor-vehicle industry would regret to see the passing of the British railway systems, and most would better appreciate their thorough modernisation, not merely in technical efficiency (about which there is really very little to question), but in commercial methods. After all, they are not asking for increased legislation, but less "control from Whitehall," a phrase which invariably begets a round of applause at public dinners. Already, many foundries and brickmakers have invested a serious amount of capital in transport vehicles, and unless the railways can put up businesslike propositions in the near future this trend will gain impetus, resulting in the possible bankruptcy of the railways, or at the least necessitating State aid for them. Foundry owners, we are sure, have no particular desire to enter into or continue in the business of carriers, but having to make a profit to remain in business, they will naturally turn to the cheapest and most convenient form of transport. Should the Government accede to the railway companies' demands, the foundry industry, with the obvious exception of that section whose business it is to manufacture motor-vehicle castings, will be anxious to learn of any propositions the railway companies have to make to ensure lower transport costs and improved service.

British Ironfounders' Association

ANNUAL DINNER IN LONDON

The Annual Dinner of the British Ironfounders' Association, in co-operation with the British Bath Manufacturers' Association and the National Light Castings Ironfounders' Federation was held at the Langham Hotel, London, last Thursday evening. Mr. W. R. Blair, the chief executive officer of the Association, presided, and was supported at the high table by Sir W. R. Dudley Pryke; Mr. Henry S. Brown; Mr. P. W. Cummings; Mr. P. Donald; Mr. C. W. Edwards; Mr. P. L. Heap; Mr. Geo. Hughes; Mr. S. B. Johnson; Capt. H. J. Kennard, R.N.; Col. Walter Macfarlane; Mr. T. A. McIntyre; Mr. Cyril N. Norton; Mr. Wm. Rennie; Mr. P. G. Rodger; Mr. Geo. Scotland; Mr. W. P. Sproul, and Mr. J. B. Forbes Watson.

Amongst those well known in technical circles who attended were Capt. J. G. Bennett; Mr. John Cameron, Junr.; Mr. L. H. Crump; Mr. H. W. Davis; Mr. V. C. Faulkner (Past-President of the Institute of British Foundrymen); Mr. V. Jobson; Mr. W. D. Joslin; Mr. W. D. Muirhead; Mr. John Oswald; Mr. J. M. Primrose; Mr. D. Sharpe; Mr. Geo. Sheffield; Mr. W. H. Smith; Mr. J. G. Sneddon; Mr. W. Todd, and Mr. A. Young.

After the loyal toast had been honoured,

MR. P. L. HEAP, of Bradford, who represented the Federation of Ironmongers, proposed the toast of the hosts in a speech which pleaded for co-operation right down from the manufacturer, through the builders' merchant, to the actual ironmonger. Amongst the many witty remarks he made, in coupling the toast with the name of Capt. H. J. Kennard, R.N., he said that this gentleman was peculiarly fitted to preside over several of the joint committees as he had spent so many years "at sea." After CAPT. KENNARD had replied, the toast of the guests was proposed by MR. T. A. MCINTYRE (of Shanks & Company, of Barrhead) in a particularly delightful speech. The reply was given by Mr. PERCY W. CUMMINGS, who represented the organised builders' merchants. He expressed

(*Continued in next column.*)

his gratitude at the sympathetic way in which the ironfounders had met their various requests. The agreement between them had been in force for five years, and whilst no period had been more difficult than the present time, he was happy in the thought that there was every prospect of long-continued co-operation at the new level of prices which had been established.

An excellent musical programme was provided during the evening, though some missed the appearance of Mr. Shanks, whose songs from the operas have been such a pleasurable feature on previous occasions.

Random Shots

When is a discovery not a discovery? Far from being another Xmas cracker conundrum, this is an agonised cry from a Yorkshire correspondent signing himself "Chilled," who is obviously puzzled as well as chilled over the claims of Mr. Allison, author of a Paper and correspondence on chilled rolls in a recent issue of the JOURNAL. Mr. Allison pointed out that most metallurgical processes have been discovered independently in many ages in many countries, but he claimed that chilled rolls were a new and isolated discovery first made in 1821, and knowledge of which has spread from place to place. The correspondent rightly reminds Mr. Allison that by the year 2821 they might easily have been rediscovered many times. Elaborating the same theme, *ad absurdum*, he pictures a time—1,000 years hence—when the ferrous alloys then the rage are all of those types which, like manganese and other steels you will know, soften on being plunged into water. At such a time a bright young metallurgist discovers that a simple mixture of iron and carbon, in which the iron exceeded the carbon 63 times, became strangely hardened when his assistant tripped with it into a bucket of water on his way back all hot from the cosmic ray heat-treatment department! And, he asks, would that be independent discovery or a spread from one place to another?

* * *

"Marksman" ventures to suggest that "Chilled" has touched upon a fundamental truth. Progress does not appear to go forward in one straight line so much as in ever-widening circles. In any one avenue, it becomes in time so complicated and so advanced that the first principles which started the circle have so long sunk into oblivion that an accidental rediscovery of the simplest phase is as inevitable as it may be startling or ridiculous, as the case may be. To take one example with which everyone is familiar, central heating is to-day being put into the higher-priced houses as a mark of luxury, whereas excavations of Roman villas in England reveal that just 1,800 years ago it was an essential. One wonders when it fell into disuse and was rediscovered. Or, take another example—the 20th century baby in the latest model nursery, surrounded by all the contraptions of modern invention. Watch him making more discoveries in ten minutes than his parents could think of in ten years. He has the grand advantage of knowing nothing and all the world is his to discover—or rediscover, as every baby in every age has done exactly the same thing. Later he becomes engulfed in that complicated sea of adult life and does not start rediscovering afresh all he had forgotten of early childhood until he reaches that sublime stage known as "second childhood." Only then is his circle complete.

* * *

Among the many toys which fathers can buy for their sons and play with themselves is a natty little "complete foundry," replete with sand, a miniature crucible, ingots and moulding boxes. It will no doubt be a great relaxation this Christmas for a few expert metallurgists to sit down and rediscover a few elementary truths about slush castings!

* * *

And that reminds "Marksman" of the quaint custom they have in Germany at Christmas time. Taking pieces of lead, they melt them and drop them slowly into water, watching with growing excitement the queer shapes formed. Each member of the family takes a piece, when set, and, according to its shape, so is his fortune predicted.

* * *

Amongst the many good stories told at the annual dinner of the British Ironfounders' Association, held last week in London, was one recounted by Mr. Heap of two youths who were being interviewed for their first job.

"Wot's t' boss like?" asked the waiting one of the boy who had just emerged from the ordeal. "Oh 'im; 'e's daft. 'E asked me three times where me 'at was, and it wore on me 'ead all t' time."

"MARKSMAN."

A SCENE AT THE ANNUAL DINNER OF THE BRITISH IRONFOUNDERS' ASSOCIATION, HELD IN LONDON LAST THURSDAY.

Making a Large Lathe Bed*

By WILLIAM Y. BUCHANAN

The casting to which the author proposes to devote this Paper is a lathe bed of constant cross-section in varying lengths; the usual is 33 ft. long, but in some cases 40 ft. when it is jointed in two sections. In all 97 castings were made in the manner about to be described, and all the data referring to metal composition and structure, etc., are based in the first 81 castings.

Method of Pattern Construction

As the casting outlined in Fig. 1 must be machined and highly-finished from end to end of the slides or shears, it must naturally be cast with this side down, although the casting is always machined on the other side as well. The general construction of the pattern is a strong box-shaped body on which the facings are mounted and the draft of the pattern is made to suit casting the shears down.

Draw bars are fitted in convenient positions in the pattern sections, and these are best fitted so that they can be either removed temporarily or made permanently below the top of the pattern, as they may, and usually do, foul the bars of the top part unless their relative positions are carefully measured before ramming up the pattern.

The facings on the sides and projecting parts of the bed shears are made loose and screwed so that they can be slackened during ramming up to allow the bed to be drawn. The long print on the bottom of the pattern serves to allow the setting of the body cores. For the purpose of camber the pattern might best be partly sawn through at intervals throughout its length and fitted with removable wedges, so that it could be bent readily; but this is not done here, as the casting is wanted in a great variety of lengths and various pieces are normally used, in which case the uniform cambering of the pattern is difficult.

The pieces actually available are the head end-piece, which is 14 ft. long, and eke piece, 12 ft., 8 ft., 6 ft. 5 in., 4 ft., and 1 ft., and sometimes four pieces are used to make up the length. These short pieces are difficult to arrange in a smooth continuous camber.

The colours which have been in use for some thirty years are *orange* for machined surfaces, *red* for the as-cast surface, and *black* for core prints. The author is unaware whether the British foundrymen intend to recommend pattern colours in the same way as the American foundrymen have done. The standard colouring would be helpful in the case of most firms undertaking outside work, and indistinct marking is often the cause of mistakes. The pattern is split so that, when in position for ramming, the base section at the head end can be removed to facilitate ramming at that part.

Moulding Box

Although some foundries might mould in a three-part box and lift it into the stove for drying, this casting is made in a long permanent box in the floor and dried with portable driers. The box itself is 110 ft. long, 5 ft. 1 in. wide and 4 ft. 7 in. deep at one end, and 3 ft. deep for the remainder of its length, as shown in Fig. 2, and is made with a permanent ash bed. The intention at first was to make the top parts and drill them with 3-ft. centres between the snugs for bolting to the box, but it was found much more convenient to clamp and wedge the top parts, which allowed their unrestricted movement.

The original method was to use a box to take the longest pattern and work one bed at a time, but the use of the very long box has many advantages for this class of casting, as, for example:—

(1) If the box is not in use (that is, the whole box or any part of it), it can be filled up and the space used for other moulding on the floor level, such as closing machine-moulded jobs, as is regularly done.

(2) Several long beds or a number of short ones can be moulded at one time. The maximum number so far is six jobs at one time.

(3) Where a number of castings are wanted off the pattern under consideration, the delivery time can be greatly improved by making an extra set of facings for the pattern. By moulding and drawing the pattern, then fitting the extra facings, moulding can be begun on the second bed while the finishing of the first is going on, so there can be the first drying, the second finishing, and the third moulding, and then the first cast, the second drying, and the third finishing, and so on in a steady sequence. In this way, for beds 30 ft. long, the rate of casting is three per fortnight.

The box was made level with the floor, and the "wings" or small frame to give the increased depth necessary at the head end were made loosely, so that it can be fixed and clamped at any position along the box.

Box Top Parts

The top parts are made in convenient lengths of 9 ft., 6 ft. and 12 ft., and the bow portion is made detachable. Although covering 6 ft., 9 ft. and 12 ft. respectively, the top parts are actually 1 in. shorter so as to allow 1 in. space, which in closing the mould is filled in with an oil-sand core. This method is preferable to laying-in pieces of round rod to chill the metal and ramming up with green sand, as this tended to chill the hard type of metal used rather heavily and caused a decided mark on the casting.

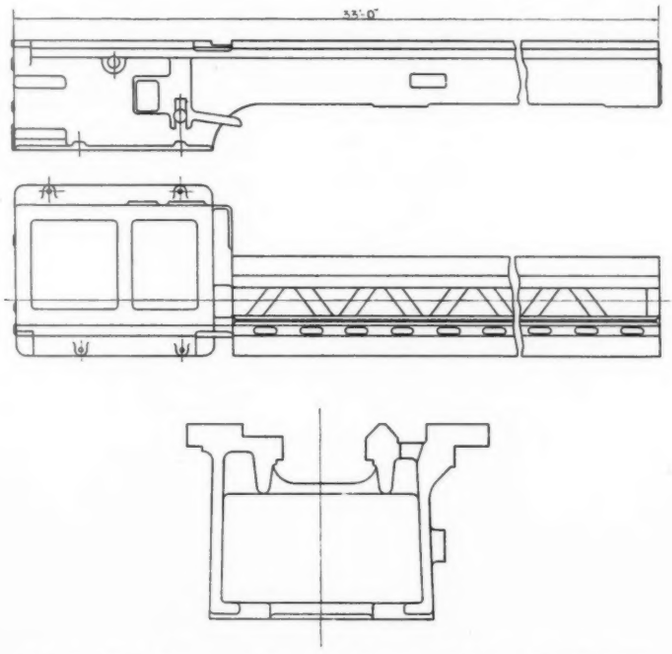


FIG. 1.—SIDE ELEVATION, PLAN AND SECTION OF LATHE BED CASTING.

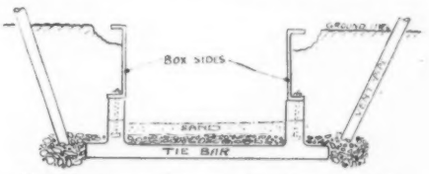


FIG. 2.—CONSTRUCTION OF MOULDING BOX.

Moulding

The ash bed is first laid in and rammed in position about the level of the bottom of the tie bars of the box, and covered with straw and sand, then firmly rammed. After the first bed has been cast, this part of the mould becomes permanent. Having rammed and levelled the sand in the bottom to the required height, the first operation is to prepare the bottom of the mould to receive the pattern, and this includes the laying of the camber. To do this, 3-ft. straight edges are placed across the bottom of the mould at intervals of 4 ft. from one end to the other. Then, using a string, the heights of these short straight edges are adjusted to give full camber in the centre, say 1⅛ in., and varying to nil at the ends.

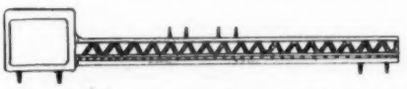


FIG. 3.—SHOWING AN UNUSUAL METHOD OF DEALING WITH SIDE CAMBER.

The short straight edges are secured at their correct height and the sand is rammed between them and struck off level, so that the camber is actually put down in a series of short straight sections altering at intervals of 4 ft. The short straight edges are then drawn and the holes filled up and levelled. The pattern is placed in the correct position in the box and the impression of the bottom prints made by bumping the pattern. Then several stakes are driven down the sides of the pattern before it is removed, so that it can readily be returned to the correct position for ramming. Long straight edges are next laid in position along each side of the impression of the print and the sand is swept out to the correct depth. The straight edges and boards are all strengthened along the working edge by strips of ⅛-in. thick metal.

■

* Paper read before the Scottish Branch of the Institute of British Foundrymen, Mr. Robert Ballantine presiding.

Where several pieces of pattern are used, it is best to use a string to set the straight edges and measure out the print. The pattern is then lowered into position and the stakes removed. A board is placed at each end of the pattern and rammed in this position to remain there till the pattern is drawn. Weights of about 10 cwts. are placed on the pattern to spring it down to the bottom, and all is now ready for ramming up.

Ramming

The bed course is first pin-rammed and then flat-rammed using a fairly high-moisture sand

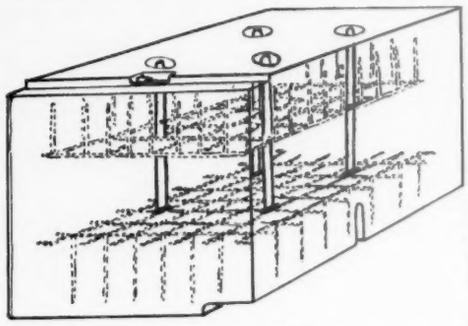


FIG. 4.—CONTRUCTION OF HEAD END CORE.

to get hard ramming, as the mould is liable to strain in this position.

For the front side, the first course is 5 in. rammed to 3 in., and the first row of straight irons is put in to support the sand above the projecting part of the shears. The second course is 4 in. rammed to 2½ in., followed by the second row of straight irons to about the centre

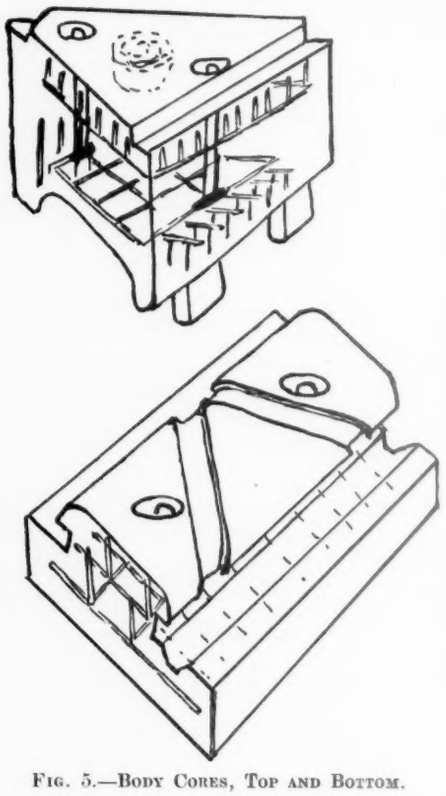


FIG. 5.—BODY CORES, TOP AND BOTTOM.

of the fillet. These two rows of irons are put within ¼ in. of the pattern.

The third and fourth courses are 6 in. ramming to 4½ in., each followed by rows of straight irons to within ¾ in. of the pattern, and the last course 4½ in. ramming to 3 in. brings the mould up level with the top of the pattern. For the parting 1½ in. is swept out to get down to the bottom of the round.

The ramming up of the back is similar except that the first course of 5 in. rammed to 3½ in. brings the straight irons up to centre of the fillet above the projection of the shears, and this is followed by three courses at 6 in. rammed to 4 in., and finishing with 4½ in. ramming to 3 in. Here again 1½ in. is swept out to form the correct parting line.

Facing sand is used for about 1½ in. from the pattern face, and the remainder is floor sand mixed on the spot. The parting is then made with a layer of wet parting sand, and the top parts are placed in position and staked for future registration. The vent pins are placed in position by the markings on the pattern and the centre and end gate-pins placed by measurement. The top parts are then rammed up by careful pin-ramming round the bars and finally finished by heavy flat-ramming. The vent-pins and gate-pins are then loosened and withdrawn and the holes blackwashed. The top parts are lifted off and turned over for finishing. The sand is carefully repaired round the top facings and sprigged round the gate holes and at the bow of the pattern, where the air and metal are liable to rush up during filling.

Where the top-parts together are longer than required to cover the pattern, the extra length is left unrammed. The operation is completed by blackwashing with swabs, dusting on plumbago and sleeking and the removing to the stoves. The pattern is next slung by the crane, rapped, and slowly drawn, leaving the facings in the mould. An extra set of facings can be screwed on the pattern and the next bed proceeded with. Meanwhile, the mould is repaired and sprigged round the facings and all along the bottom of the mould, *i.e.*, the face of the shears. The mould is then blackwashed, and plumbago liberally applied and sleeked on to give as good a finish as possible.

Side Camber

Cast normally, the side camber on a bed of this type would be considerable—probably 1½ in. in 33 ft., and as already explained the usual method of putting the camber on the pattern is not convenient when the pattern is in a number of pieces. The method used is to anchor the casting securely to the box and prevent any distortion during cooling. Blocks of cast iron are rammed up at a level with the shears, *i.e.*, on the first ramming course, with one side against the box and the other about 6 in. from the pattern. A piece of wood about 2-in. square is placed between the block of metal and the pattern, and this is tapered to draw inwards and so leave a projection on the casting which will bear directly through the block on to the moulding box. The bulging side is anchored in the centre by four of these suitably placed, and on the other side the ends are anchored. (Fig. 3.)

This method is now the usual practice and turns out a casting within about ⅛ in. of the pattern shape. It is also quite flexible in that the number off, distance apart, and position of these metallic buffers can be varied at will. In drying the mould cast-iron plates are used for covering the mould, and some of these plates have suitable openings through which the heated air can be blown. After claying up the spaces between the plates the mould driers are placed, one in the centre, one near the tail end, and the other just outside the head end.

The ends are closed with cast-iron plates so as to leave openings for gases to escape at the lowest point. Under the centre and tail-end mould driers, a short cast-iron pipe is used to direct the hot air down past the sides of the mould, then allowing it to escape parallel to the mould length only.

In drying, the head-end and centre driers are put on for 18 hours, to be followed by the head and tail-end driers, for 9 to 12 hours. It was found best to have these mould driers made with screw-controlled dampers which allow a fine degree of adjustment. The lower dampers can only be used for kindling, *i.e.*, all air goes over the fire or the mould will be burnt. The dried core in the head end is covered with paper and wet loam to protect it from over-drying. These driers burn about 20 lbs. coke per hr. and are fired regularly every 1½ hr. The cost of drying a 33-ft. bed is for fuel 12s. 4d. and for electricity 1s. 4d.

The system of recording the exact time of each fire and checking the weight of fuel is the best control of firing that can be had. It might be worth while to install pyrometers in the air stream, but the existing scheme works perfectly with the screw dampers, which were made on

FIG. 6.—END CAKE CORES.

request some four years ago. The danger of "burning" the mould was always due to lack of control of the small push dampers and the liability to shift during working.

Head-End Core

The core box is open top and bottom and is rammed up in the normal casting position. The lower grid is cast with four lifters spaced suitably, and the bars of the grid form 4½-in. squares with 9-in. "dabbers" and 7 in. as shown in Fig. 4. The metal in this grid and the frame is of the usual D-shape, 1 in. broad by 1¼ in.

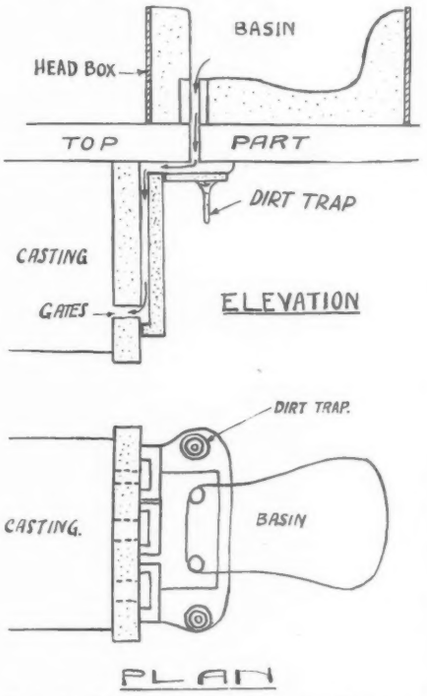


FIG. 7.—METHOD OF GATING AND POSITION OF END CAKE CORES.

deep. The sand is carefully rammed up to about half-height, and the frame put in with "dabbers" upwards. This frame has bars forming 8-in. squares at the ends and 6-in. squares in the centre, and, unlike the lower grid—which has dabbers to every square—has dabbers only round the side, 6 in. long and 5 in. apart.

The ramming is continued to the top and the centre filled in with ashes. The box is then loosened and taken away, and the core finished and sprigged along the fillets and on the edges of the prints. The core is then suspended and sprayed with blackwash and finished by painting over, using a flat brush. It is removed to the drying stove and dried two nights at a temperature of 600 deg. Fah. (315 deg. C.) maximum, no drying being carried out during the day.

Body Cores

The body core was at first split vertically, *i.e.*, put in as one core, but the method of using two cores illustrated in Fig. 5 was found best for many reasons.

The top half is rammed up with a grid and frame as shown in Fig. 5. The grid has two 9-in. lifters and 4½-in. dabbers on one side above the plugs. A single straight iron is rammed up on the opposite side to strengthen the projection on that side. The frame is of similar shape and has 4½-in. dabbers, and is rammed up in the core with the points upwards. An ash vent is put in the centre of the top face and the core is sprigged along the fillets and on the plugs and projection on the opposite side.

Every alternate body-core top-half is turned the opposite way in the mould and is exactly the same, except that it has no plugs projecting from the lower side. These cores are vented through the top part of the mould. Longer cores are used at head- and tail-ends, shaped to finish off square. These are, however, essentially the same as far as coremaking is concerned.

The lower core (Fig. 5)—referred to as the bottom print core—is made in standard lengths of 23 in., with the one at the head end 3 ft. long. The grid used has two 7-in. lifters and two rows of "dabbers" 6 in. long. These cores are sprigged on the edges and fillets, and, in addition, those nearest the gates at the tail end are sprigged along the flat faces along which the metal runs. These cores are vented through the bottom into a clearance in the bottom print, which is vented direct to the ash-bed.

End Cake Cores

These cores, shown in Fig. 6, are used to form the ends of the mould, and are made 6 in. thick and 4 in. thick, through which are cut the inlet gates. They are made by jolting in an open top box which carries the facings on the end of the bed. The head end core is 6 in. thick and has a grid covered with 5-in. dabbers and 5-in. lifters. Spaces are left in the grid for the gates, and the pins are located by measurement. The tail-end cake core is 4 in. thick and has 3-in. dabbers and three 3-in. lifters.

Closing

The head-end core is laid in first, then the lower body cores are butted to this in succession towards the tail end. Careful alignment of these cores is essential, as they form part of the contour of the slides, or shears. These bottom cores are set on a light loam stamp and vented direct to the ash-bed. The body cores are set from the head end onwards and are secured by chaplets, the height being fixed by the same stick as that used to sweep out the parting.

After examining from end to end through the open ends, the cake cores are placed with the gates in the correct position so as not to cause the metal to strike the mould on the cores. The upright cores which form the down gates are placed in position, loamed up and rammed in position, taking care to wedge the bottom tightly from the solid sand and using convenient plates to take the pressure. After ramming to near the parting, a dry-sand cake is placed in position to take the force of the metal dropping from the down gates from the basins. The space between this dry cake and the top parts is 1¼ in. Dirt pockets are placed at the sides of the dry cake, as shown in Fig. 7.

Loam stamps are placed round all core vents, round the mould sides, and also round the gate areas at the parting. The top parts are brought over and tried on, dropping whitening down the gates and vents before lifting off again in order to test the position of the down gates and vents. The stamps are trimmed off, the vents filled in with loose green sand, and the mould finally examined for any trace of detached sand, for which purpose a small electric lamp on a long tube is used.

Having replaced the top-parts, the making-up of the risers and pouring basins is begun. Hollow cylindrical cores are carefully placed in position, so as to extend the down gate from the top-part up to the level of that required for the bottom of the basin. The head box is placed in position, and the basin rammed up and cut out to shape such that both end basins have the down gates close to the side of the basin to prevent swirling of the metal during pouring. The centre gates are built up in the same way, but a long trough basin is used to take in the gates on either side of the mould. This basin is filled from the adjacent bay by means of a suitable runner, which is kept dried ready for the purpose. The down gates in this basin are plugged with stoppers until the basin is well filled, and then the flow of metal is released, as it would otherwise be difficult to keep up the metal level.

The four risers on the head end are made up to the required height with a series of square cast-iron frames in the usual way. Six extra risers are taken off the body section of the mould. These are cut back from the facings situated along the top of the casting, and brought up through the top part to the required level. Their function is to help to free the mould of air which tends to become trapped during rapid filling. Heavy cast-iron weights in the form of long bars are laid along the sides of the top parts after clamping securely and the intervening space rammed up. Without this precaution the metal is very liable to get out at the parting. Four weights of about a ton each are placed on the top parts as an additional safety measure, and these to some extent prevent straining of the top parts in the final filling stages.

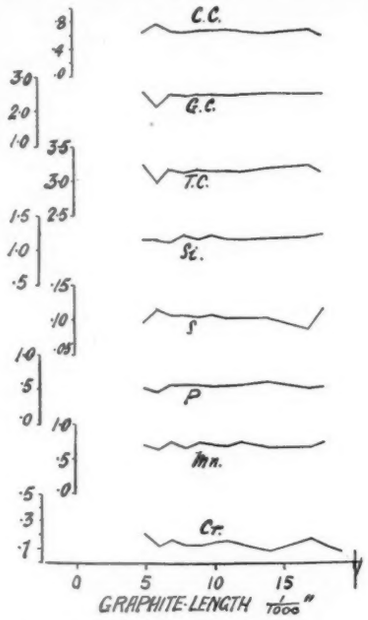


FIG. 8.—RELATION BETWEEN GRAPHITE LENGTH AND ANALYSIS IN 81 CASTINGS.

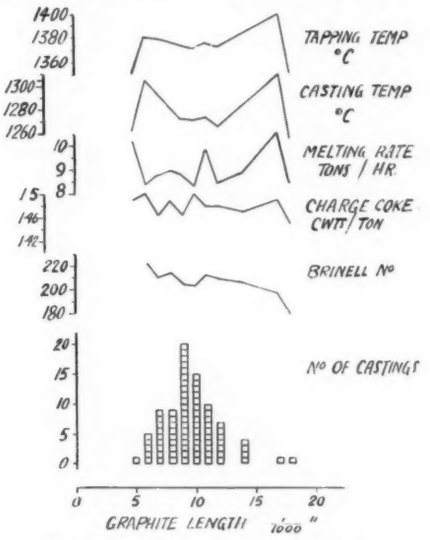


FIG. 9.—RELATION BETWEEN GRAPHITE LENGTH AND MELTING CONDITIONS, BRINELL HARDNESS, ETC.

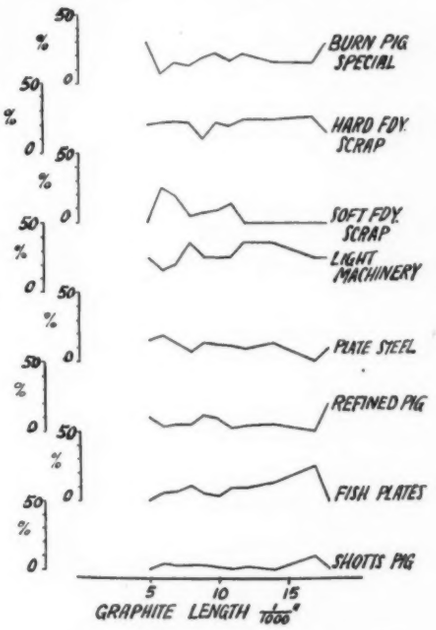


FIG. 10.—RELATION BETWEEN GRAPHITE LENGTH AND TYPE AND PERCENTAGE OF RAW MATERIALS IN CUPOLA CHARGE.

Gate Dimensions

The gates at the head end consist of three rectangular inlets, 2⅞ in. by ⅞ in. at the casting, fed by uprights 4 in. by ⅝ in. Those at the tail-end consist of two measuring 2½ in. by ⅞ in. and one 2 in. by ¾ in. The first two are fed by a single upright 9 in. by ¾ in. and the other by an upright 4 in. by ⅝ in. The centre gates consist of one each side of the centre.

Rate of Casting

This casting is best cast quickly, and the rate used for those referred to is 6 tons per minute. The object is to cover the bottom and fill the shears as quickly as possible, but, as there is a relatively light section above this, with rapid filling the metal is certain to rise too quickly toward the top and may strike the top of the mould with considerable force.

The use of three ladles is preferred to, say, one large ladle collecting all the metal, as this cannot give such uniform cooling conditions. With three ladles and a continuous tapping system the metal can be conveniently collected

and cast with not more than 20 or 30 deg. C. difference in temperature. By starting all three ladles together and allowing one to empty early, the rapid filling of the lower heavy section can be accomplished with a somewhat slower filling of the lighter upper sections of the mould.

If this rate be not checked towards the end a small quantity of metal is shot up to the roof, which, although it does no harm to the mould, is very annoying to those who have to be near.

Lifting

The bed is usually cast at 4 p.m. Next morning the top parts are lifted off and the gates broken off and the centre part only covered with hot sand. Then the casting is lifted in the afternoon of the following day. A typical sequence is: Cast, Tuesday, 4 p.m.; gates broken, Wednesday, 10 a.m., and lifted, Thursday, 2 p.m.

Precautions and Possible Defects

The inspection and standard of quality required seem to go far beyond what is usually expected in foundry work. A small surface defect in the shears which could not possibly interfere with the usefulness of the casting would cause rejection on the grounds of appearance alone.

As is well known, a percentage of defective castings accompanies all foundry work, but it is highly desirable that this percentage confines itself to something less important than the casting herein described. The defects to which this casting is liable may be listed as follow:

(1) Chaplets becoming dislodged and falling into the shears, where they may appear in the machined surface.

(2) Inferior coating on chaplets causes gas holes. Only the best coatings of pure tin have been found suitable, and the quality of this coating is checked by analysis.

(3) Defects due to detached sand during closing.

(4) Scabs due to incomplete drying. As stated elsewhere, these do not appear due to expansion in normal circumstances.

(5) Burning of the mould sides results in bad surface defects accompanied by washing.

(6) Washing may occur under the gates along the shears if the sand is not hard rammed and of good dry strength. This defect is guarded against by sprigging along the entire length of the shears.

(7) Scaling of blackwash is a source of dirt inclusions on the casting surface. This is usually due to weak sand condition or faulty blackwash mixture, and is largely eliminated by the use of a proper mixing machine to replace the old method of mixing by hand in an open tank.

(8) Gas holes may result along fins formed by excessive clearance on the partings, which may be aggravated by lack of fluidity in the metal after casting, and also by low temperature.

(9) Low Brinell hardness, which is fatal with some inspectors. This can only be overcome by control of tried and proved composition, casting and melting conditions.

(10) "Open" machined surface which can occur even with good Brinell hardness. This is controlled to a large extent by the form and quantity of graphite in the iron.

(11) Chilled edges are an ever-present source of possible trouble. These might be largely eliminated with the fins, as a much harder iron can be used where there are no fins.

(12) Lack of machinability due to the presence of pro-eutectic cementite. This may result from a fairly small excess of chromium over the low percentage required with low-silicon, low-carbon iron.

Use of Chills or Denseners

It should be noted that no chilling is done on the surface of these beds, and the hardness obtained by the proper composition and melting conditions has a very high uniformity in heavy sections. A casting made in this way is much less subject to strains; distortion is more uniform on machined surfaces even if the camber does not turn out as expected.

Metal Control and Composition

Besides the regular analysis of samples taken from each ladle, a test-piece is cast on the shears and of the same thickness as the shears, so that the conditions of cooling will be the same. This test-piece is planed down with the bed so that the surface of the machined test-piece will be the same depth below the casting skin and have the same structure. The test-piece is numbered before leaving the foundry and when cut off is sent to the laboratory. On this the Brinell hardness is checked and the micro-specimen cut from the machined surface. The micro-specimen is numbered on the reverse side and, after examination, filed for reference.

Since the degree of closeness of the machined surface is directly affected by the size of the graphite flakes, the actual measurement of these is made in order to give some numerical value to this property. Thus, to say that the 81 castings represented in the graphs have an average graphite length of 6.8 thousandths of an inch gives a definite idea of the size of the minute cavities made in the surface during machining, since the pieces of metal when torn out break away along the graphite plates.

A surface which would be described by the machinist as open, is associated with graphite length of 50 thousandths and often with free ferrite. The figure taken for each micro-specimen is the average of 10 measurements. The method, like many others, may be unreliable on a small number of cases, but if carefully done on a large number, as in the data under consideration, gives useful conclusions. Since the closeness of finish is the most sought-after property, the other data have been graphed against this in order to show, if possible, which conditions or sets of conditions favour small graphite size.

In the case of the chemical analysis, as in the others, the points on the graph (Fig. 8) are the averages of all the castings having the same graphite size. It will be seen that the graphs are remarkably flat and that graphite size within the range found is independent of composition, that is, of course, provided the composition is controlled to close limits. The majority of castings will be observed to have graphite less than 11 thousandths in length, with one at 5 thousandths which may be accounted for by the slight excess of chromium; but for general conclusions it may be best to neglect single cases.

The Brinell hardness is seen from Fig. 9 to fall as the graphite size increases, which can be readily accepted. A lowering in the percentage of coke charge per ton of iron during melting appears to be accompanied by a drop in casting temperature and an increase in graphite size, which may support the theory that high melting temperature re-dissolves graphite more completely than low melting temperature. The type and percentage of raw materials may be expected to have some effect on this graphite size.

From Fig. 10 it will be seen that there is a tendency to increased graphite size with increased steel and with remelting the same material, but on the whole they seem to have balanced one another out very well. It should be remembered that all of these factors operate at once and that the object here has been to prevent variation as far as possible and to maintain as small a graphite size as is possible, consistent with avoiding the other physical defects which may occur due to metal conditions which are unsuitable to good foundry practice by carrying this pursuit too far. Also, this group of castings covers a period of 3 years, with its varying market conditions, etc. However, it may be said with some satisfaction that the 97 castings referred to had none of the defects listed or described, and they might be modestly called good castings.

DISCUSSION

Coring and Blocking

MR. R. D. LAWRIE said he had no experience of making lathe beds, but he would like to express his appreciation of the Paper Mr. Buchanan had presented to the meeting. Remarking on the fact that Mr. Buchanan had based his Paper on observations on 81 castings, Mr. Lawrie said that, had he been in the author's place, he would have adopted standardised methods in order to cheapen production, *e.g.*, coring out the sides of the mould, but he added that he noted that had already been done to some extent.

MR. BUCHANAN replied that he had applied coring and blocking-out very extensively to increase production rate to such an extent that the drying equipment now represented a bottle neck. There had been ample scope for it on the other castings; *e.g.*, small beds were split and dumped up in halves up to 9 ft. long, but he thought it would be more expensive to set cores along the sides and would not leave a very good surface, owing to the joints of those cores. The adoption of standardised methods was difficult in this case, as the firm usually got small numbers of castings, and they were wanted in different lengths.

Testing Chaplets

MR. ROSS said that Mr. Buchanan's experience with chaplet coatings confirmed his own experience of defects due to chaplets.

MR. BUCHANAN said he had found a good coating on the chaplet to be important in the making of these castings. He regularly tested chaplets by melting off some of the coating with a clean gas flame and effecting an analysis on the small bead of metal thus obtained. The method readily showed the difference between a pure tin coating and a cheaper type. Several cases of defects were found when pure-tin coated chaplets could not be obtained and cheaper coated chaplets had to be used temporarily.

Casting Methods

MR. MARSHALL doubted whether the mould could be efficiently dried for 13s. 8d. with coke at 33s. per cwt. He wondered whether Mr. Buchanan, when using three ladles, had experienced trouble due to dirt, especially when one of the ladles was emptied earlier than the others. He also asked if the wash of metal in the mould when using a ladle at each end had any influence in causing dirty castings.

MR. BUCHANAN assured Mr. Marshall that efficient drying was obtained, and added that mould-drier fire-boxes had been modified as regards grate area. Inefficient drying would certainly result in a defective casting. There was a tendency for dirt to be trapped if the metal was cold, and this was a trouble which had to be overcome in his earlier experience. In allowing one ladle to be emptied before the others, the head of metal did not allow dirt to get into the casting.

Core Mixtures

MR. LITTLE asked if Mr. Buchanan had ever used a copper addition to prevent chilling at joint fins; in his own experience he had found 1 per cent. helpful. He suggested that the coke/iron ratio used by Mr. Buchanan was too low and likely to lead to trouble. He asked the author for details of the core mixture used.

MR. BUCHANAN said he had not used any copper addition, as he found it unnecessary. He confirmed that with under 1½ cwts. coke per ton of iron he got the best possible conditions of melting. This figure was readily obtained in his balanced-blast cupola. The core mixture in use at present he gave as floor sand with under 1 per cent. Colbond and no other additions. This gave the following average figures:—Green strength, 4 lbs.; permeability, 73, and dried strength, 100 lbs.

In reply to Mr. McManus, MR. BUCHANAN said that the runner box used was a plain type with no special provision for dirt trapping. The

(*Continued on page* 454.)

Electric Furnace Practice in the United States*

By W. M. FARNSWORTH and E. R. JOHNSON

The electric furnace is used for the manufacture of many steels in the United States. Several types of electric-furnace construction are in use, and of these the predominating types are the conventional Héroult arc and the high-frequency induction furnace. Low-frequency induction furnaces are few. The largest of them (6 tons) is located at the Canton Works of the Republic Steel Corporation. The Héroult arc furnaces may have either basic or acid bottoms, and generally it may be stated that the ingot-producing furnaces are basic, while the foundry furnaces for castings have acid linings. These furnaces are extremely varied in size up to 100 tons, with conventional sizes of 6, 15 and 25 tons capacity.

TABLE I.—*Particulars of Various Furnaces.*

Furnace capacity, tons.	Transformer capacity, kva.	Voltages—High.	Voltages—intermediate.	Voltages—Low.	Graphite electrode, dia., in.	Hearth area, sq. ft.
25	10,000	240	180	115	18	100
15	4,500	220	170	110	14	64
6	2,800	180	—	110	12	40

In the United States the arc furnaces are used for the manufacture of many grades of steel for the purpose of obtaining quality, uniformity of product, close chemical control, and special and complicated analyses. Many of the special carbon tool steels, the highest quality alloy steels, the aircraft steels, the semi- and full corrosion-resistant steels, the special heat-resisting steels, the alloy tool steels and the high-speed steels are made in the basic arc furnaces.

Equipment

At the Republic Steel Corporation plant at Canton there are one 25-ton, three 15-ton (Fig. 1) and one 6-ton arc furnaces, all basic lined, and in addition one 6-ton, low-frequency induction furnace, basic lined (Fig. 2). They are used to produce special carbon steels, alloy steels of all analyses, and low- and high-corrosion-resistant alloys. The largest production includes the anti-friction bearing steels (high-carbon chromium and low-carbon alloy) aircraft alloy steels and semi- and full corrosion-resisting alloy steels.

The 25-ton arc furnace was installed in 1930 and is of the latest design. The 15-ton and 7-ton furnaces are of an older design. All of the arc furnaces are equipped with the most modern automatic electrode control regulators. The arc furnace transformer capacities, voltages, size of electrodes and hearth areas are shown in Table I.

These furnaces are supplemented with all necessary facilities to permit efficient operations. The raw materials are stored in convenient and easily accessible places. Scrap is loaded by magnet cranes into charging boxes, which are delivered by narrow-gauge track to the furnace building. Two charging cranes are available for charging scrap into the furnaces. The furnace building has three ladle cranes for handling and pouring the steel into the ingot moulds. Space is also available in the furnace building for ladle care and for mould preparation. Secondary ladle equipment can be used when double-pour operations are desirable.

Furnace-Hearth Construction

Because of the high temperatures and high-lime slags carried in the arc furnaces, the lining, and particularly the hearth, is a problem that has been given intensive study. The hearth is subject to cracking and slag penetration, which are the sources of most hearth difficulties. While, to the authors' knowledge, the difficulties have not been entirely overcome, their company have developed a hearth lining that has given better results than the ordinary magnesite or dolomite bottoms, which were burned in layer by layer or rammed in with a suitable binder.

The sub-hearth is installed in much the usual way, with a flat course of firebrick against the shell, on top of which are laid several courses of magnesite brick extending up the side wall to just above the slag line. The side walls and roof are lined with silica brick.

The mix for the working hearth is made up with 80 per cent. of graded periclase grain and 20 per cent. of finely-ground Austrian magnesite, to which is added liquid silicate of soda for a binder. The periclase is a magnesium-oxide grain that has been burned at a high temperature to give approximately the same chemical and physical properties as fused magnesium oxide. The mix is graded as follows:—20 per cent. ½ in. to ¼-in. mesh periclase grains, 90 per cent. MgO; 20 per cent. ¼ in. to ⅛-in. mesh periclase grains, 90 per cent. MgO; 40 per cent. ⅛-in. mesh to fines periclase grains, 90 per cent. MgO; 20 per cent. $\frac{1}{16}$-in. mesh to fines dead-burned Austrian magnesite, 83 per cent. MgO.

This mix will require slightly over 5 quarts per cwt. of liquid silicate of soda to form a good plastic mix for ramming. It is rammed in layers of 2 to 3 in. at a time until the hearth is up to the required thickness and contour. It is then dried for 24 hrs. with a wood fire, after which the arc is applied and the furnace is brought up rapidly and held at a temperature just below that which would cause the silica brick in the side walls and roof to drip. After 24 hrs. of this heating, the bottom will be sintered to a depth of 3 to 5 in. It is then ready for operation and will become completely sintered through with use.

Furnace Operation

Raw Materials.—The raw materials include scrap, ferro alloys or other forms of alloying elements, oxidising agents, carburisers, and any material used for making slags. The heavy melting scrap is largely accumulated in the authors' own plant from blooming-mill crops of low-carbon steel or from ingot irons. Some light

TABLE II.—*Typical Analyses of Slag-Forming Materials.*

	CaO	SiO_2	MgO	SO_3	R_2O_3	Ignition loss.	CaF_2	S	Ash.	Al_2O_3	Fe_2O_3
Lime ..	91.48	1.29	1.02	0.105	0.94	5.30	—	—	—	—	—
Fluorspar	6.50	5.00	—	—	—	—	84.50	0.02	—	—	—
Sand ..	—	98.24	—	—	—	—	—	—	—	0.40	0.96
Coke ..	—	—	—	—	—	—	—	0.60	11.00	—	—

FIG. 1.—15-TON ARC FURNACE AT CANTON WORKS, REPUBLIC STEEL CORPORATION.

* Paper (slightly abridged) presented at the Autumn Meeting of the Iron and Steel Institute in London.

scrap is purchased. Scrap containing alloy elements is sometimes used to permit alloy recovery.

The condition of the scrap is very important in electric-furnace practice, as it can influence the element quality of the finished product. Therefore, every effort should be made to utilise

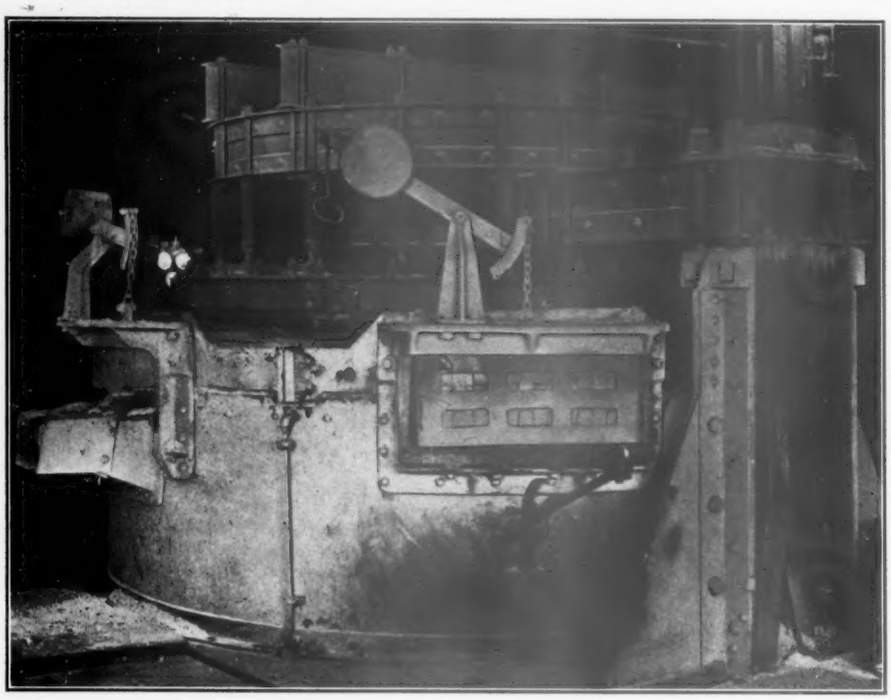


FIG. 2.—6-TON LOW-FREQUENCY INDUCTION FURNACE AT CANTON WORKS, REPUBLIC STEEL CORPORATION.

and select the best scrap, for both its physical appearance and its analysis.

The ferro alloys and other alloy elements are purchased to specified chemical compositions. These include ferro-chromiums of varying carbon content, ferro-silicons, ferro-manganese, ferro-vanadiums, ferro-tungsten, ferro-titanium, ferro-molybdenum, calcium molybdate, ferro-columbium (ferro-niobium). Aluminium is available in several forms to provide suitable additions for either alloying purposes or deoxidation.

The slag-forming materials are lime (burnt), fluorspar, silica sand and coke (crushed). Typical analyses are given in Table II (per cent.).

Alloy-Steel Practice

Melting Procedure.—The furnace is charged first with selected heavy scrap and then with the lighter scrap. In the case of high-nickel steels, a large portion of the nickel is charged along with the scrap. The placing of the scrap in the furnace and the proper proportion of light and heavy scrap are important from the standpoint of bottom difficulties and rapid melting. Sufficient carbon, in the form of anthracite coal or ground carbon electrode, is charged in with the scrap, so as to produce a vigorous boil with the addition of iron ore. The charging of a large amount of lime or limestone with the scrap will retard melting. It is preferable to shovel in burned lime during the melting. The melting is done as rapidly as possible. High voltage is used for the first hour and a half of melting. Since the high voltage throws a large arc and would damage the side walls and roof after the scrap is under cover, the intermediate voltage is used when partly melted and low voltage when completely melted. In the case of molybdenum steel, calcium-molybdenum is added during the melting. Ore is added in the furnace just before and just after the scrap is completely melted. When the charge has completely melted and the boiling action from the ore has subsided, tests are taken for analysis. The carbon is determined quickly by means of a carbometer, after which the making of the heat progresses while the chemical laboratory analyses other elements, such as manganese, nickel, molybdenum, etc. Since the scrap charge is of known composition, there is little chance of these elements not being within the desired limit, or in such amounts that they cannot be brought within the specifications. So, when the carbon is oxidised to a desired point, the oxidising slag is removed.

Refining Procedure.—Slag may be removed very efficiently with either wood or steel rakes. As a matter of economy, wood is preferred where cheap timber is obtainable. After the slag has been raked off clean, the carbon is adjusted to the point desired by adding ground carbon electrode to the bare metal. This form of carbon is preferred to coke or anthracite coal because of its higher specific gravity. It is absorbed more quickly in the metal and the final slag mix may be added immediately afterwards.

The materials used in the final slag mix are lime, sand and fluorspar, with sufficient coke to form calcium carbide. The amount of lime used, which should be adequate to form a protective covering over the bath, is 2 per cent. of the scrap charged. Fluorspar and sand are used in amounts to form the quickest possible flux with the lime. Too large a slag volume will make it more difficult to carry a high temperature in the bath. The lime, fluorspar and sand are mixed on the floor and shovelled into the furnace immediately after the bath has been recarburised. Crushed coke is then spread over the surface of the slag. Sufficient coke to form and maintain calcium carbide in the slag may be approximately 20 per cent. of the total slag mix, but will vary according to the conditions. The object is to form as quickly as possible a strong reducing slag, containing over 2 per cent. of calcium carbide, and maintain it so throughout the refining period. Ordinarily the sulphur will be as low as 0.015 per cent., and sometimes it is necessary to produce analyses with lower sulphurs. To do this consistently, it is necessary to watch the carbide slag to make sure that it is thoroughly reduced with a strong carbide content. In many cases it may be necessary to work the heat under a second carbide slag.

As soon as the slag is uniformly reducing over the entire bath, tests are taken for a check analysis. Nickel and ferro-molybdenum, based on laboratory results from tests taken after the melt-down, are added at this point to bring these elements within the desired limits. The metal is kept at a high temperature and ferro-chromium is not added until tests indicate that the temperature is sufficiently high. Before each test, and periodically, the metal bath is thoroughly stirred with steel rods. When the laboratory results from the final tests are received, the necessary additions are made. Any necessary carbon addition is made with special low-phosphorus pig-iron. Manganese and silicon are the last additions before tapping. A log of a normal alloy-steel heat is given in Table III.

(*To be continued.*)

TABLE III.—*Arc-Furnace Record of Normal Alloy Heat.* (*15-ton Furnace.*)

Analysis ordered: C, 0·15–0·20%; Mn, 0·40–0·60%; S, 0·025%; 0·025%; Si, 0·15–0·30%; Cr, 0·45–0·75%; Ni, 1·00–1·50%.

8.30 A.M.	Previous heat tapped.
8.40 A.M.	Began charging: 36,000 lb. common scrap. 265 lb. nickel. 120 lb. anthracite coal.
9.10 A.M.	Finished charging; power on high voltage.
10.10 A.M.	Add lime, 300 lb. Intermediate voltage.
11.00 A.M.	Add lime, 300 lb. Low voltage.
11.15 A.M.	Add iron ore, 200 lb.; nearly melted.
11.25 A.M.	Add iron ore, 250 lb.; completely melted.
11.40 A.M.	Bath stirred. Carbometer test 0·06% C.
11.42 A.M.	First steel and slag test.
11.45 A.M.	Start slag off.
12.00 noon.	Finish slag off.
12.08 P.M.	Refining slag mix added: 800 lb. lime. 150 lb. fluorspar. 100 lb. sand. 90 lb. coke.
12.20 P.M.	First steel test reported: 0·16% Mn, 0·012% P, 0·77% Ni, 0·04% Cr.
12.30 P.M.	Add coke, 90 lb.
12.45 P.M.	Bath stirred; slag carbide.
12.50 P.M.	Second steel and slag test.
12.55 P.M.	Add coke, 50 lb.
1.10 P.M.	Stir bath; temperature test.
1.15 P.M.	Add chromium, 270 lb.: 70·00% Cr, 4·60% C.
1.20 P.M.	Add coke, 40 lb.
1.30 P.M.	Second steel test reported: 0·08% C, 0·15% Mn, 0·026% S, 1·24% Ni, 0·05% Cr.
1.35 P.M.	Stir bath; temperature test.
1.40 P.M.	Add manganese, 182 lb.: 80·00% Mn, 6·70% C.
1.40 P.M.	Add silicon, 106 lb.: 76·00% Si.
1.55 P.M.	Power off; stir bath; temperature test.
2.00 P.M.	Tapped.

Ladle Analysis.

0·17% C, 0·57% Mn, 0·013% P, 0·015% S, 0·22% Si, 1·22% Ni, 0·57% Cr.

Slag Analysis.

	CaO. %	SiO_2. %	FeO. %	Fe_2O_3. %	Al_2O_3. %	MgO. %	MnO. %	P_2O_5. %	S. %	CaC_2. %
First	38·59	10·52	18·16	6·44	2·20	8·00	9·28	0·59	0·14	...
Second	60·86	17·30	0·97	Nil	0·72	4·10	0·40	Nil	0·31	2·40
Tapping	63·74	20·19	0·58	Nil	0·30	8·25	0·10	...	0·32	2·00

High-Duty Cast Iron

By J. ARNOTT*

In the following notes, high-duty cast iron may be defined as cast iron having a dependable strength of over 20 tons per sq. in. MacPherran,[1] who has written some very valuable articles on the subject, puts his minimum figure at 22 tons per sq. in. The British Standards Institution has recently issued a specification for "High-Duty Cast Iron."[2] Three grades are included in this specification, and the highest figure called for is 22 tons per sq. in. This refers to the 0.875-in. dia. test bar in the highest grade. In the commonly used 1.2-in. diameter bar, the tensile strength minima are 20, 17 and 14 tons per sq. in. respectively. The 1.2-in. diameter bar was used in all the tests referred to in this note.

High-strength cast iron can be made in various ways, by direct cupola melting, duplexing in electric furnaces, cold melting in oil or electric furnaces, etc. Naturally, where possible, one wants to use the cupola, and it is rather surprising what can be done with a cupola of suitable type in skilled hands. There is little doubt that the degree of control exercised in some American foundries helps to explain the regularity of the results attained in the production of high-quality work. In this country, many cupolas have several rows of tuyères and hence a deep coke bed. These are probably not so suitable for high-strength iron as the single-row Whiting type.

A small electric furnace or an oil-fired crucible furnace can be profitably used for exploratory work and small-scale production. The greater part of the data referred to in this article is the result of a series of over 150 melts in a rocking arc furnace of 350 lbs. capacity. (Most of the purely experimental section of this series has been reported by B. McDougall.[3]) Among the earlier melts, about twenty were made to determine the relation of total carbon and silicon to strength. All these melts were made completely from steel scrap, carburised with a suitable form of carbon and without alloy additions except the desired amount of silicon and a small constant amount of manganese.

Influence of Carbon

Surveying the results, the first conclusion is that total carbon is the predominating factor. The relation of the total carbon to strength is shown in Fig. 1. There it will be seen that strengths of over 20 tons are obtained if the total carbon is under a figure of approximately 3.1 per cent. Beyond this carbon content, the strength falls away rapidly. It is noteworthy that even in iron made from steel scrap and melted in an electric furnace the strength is only 10 tons per sq. in. when the total carbon reaches 3.7 per cent. The basis of high-strength iron is essentially an iron of low total carbon.

In ordinary cupola iron of around 3.5 per cent. total carbon, the silicon content has a strong influence on the hardness and strength. In fact, it may be said that in engineering foundry work at any rate, reliance is largely placed upon "silicon control." Below about 3 per cent. total carbon, silicon ceases to have the same controlling influence, provided there is sufficient to prevent the iron from being white or mottled. In the case of two melts with 2.2 per cent. total carbon, one with 2 per cent. silicon gave 25.2 tons per sq. in., while one with 3.9 per cent. silicon gave 25.9 tons, although the hardness was considerably lower.

Uses of Nickel

Starting with low total carbon metal, one can proceed to alloy it for improvement either in strength or in some other property. Nickel has proved so useful in ordinary cupola iron that one naturally turns to it as a first choice. In the writer's opinion, the value of nickel is not simply in the added strength obtainable thereby, but in the general "foolproofness" which it confers. The prevention of chill and mottling is a very valuable advantage if the total carbon cannot be controlled to fine limits. Suppose, for example, a total carbon content of 2.6 per cent. is desired, and the melt proves to be 2.3 per cent., the resulting casting may be mottled at thin sections. A nickel addition of between 1 and 2 per cent. offsets such variations. In the experimental melts, the increase in strength due to nickel additions varied, as might be expected, in a series with a fair range of carbon and silicon contents. In all cases there was an increase, and the average was of the order of 4 tons per sq. in. Another feature of nickel additions might be mentioned here. In ordinary cupola irons, it is usual to make a reduction in the silicon content if nickel be added. In low carbon iron there is not the same need to adjust the silicon content to balance the nickel additions.

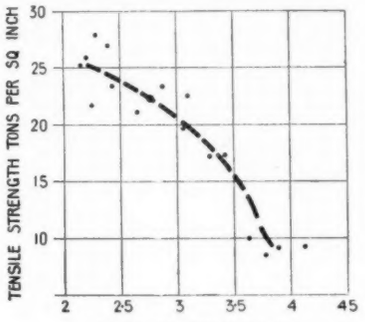


FIG. 1.—RELATION BETWEEN TOTAL CARBON AND TENSILE STRENGTH. (ELECTRICALLY-MELTED ALL-STEEL CHARGE WITHOUT ALLOY ADDITIONS.)

Many heats have been made with molybdenum additions for reasons other than increased strength. Since molybdenum is of the carbide-stabilising group, one would expect it to be suitable for castings subjected to medium steam temperatures, *i.e.*, of the order of 400 deg. C.

Nickel and molybdenum together give promise of properties which are attractive in many directions. Strengths of 30 tons per square inch and upwards were obtained from melts containing: Total carbon, 2.6 to 2.8; silicon, 1.5 to 2.0; nickel, 2.0; and molybdenum, 0.5 per cent.

A feature of this group is the very good impact resistance. Unfortunately, no tests for either single-blow or repeated impact suitable for high-quality cast iron have been standardised and one hesitates to quote figures. However, repeated impact tests on a nickel-molybdenum iron coming within the range mentioned above gave a figure of a totally different order from that usually obtained on ordinary iron of, say, 12 to 15 tons per sq. in.

Cupola Melting

The final aim is to use the cupola for ordinary production wherever possible. Here it might be remarked that, comparing electric furnace melts with cupola melts, no essential differences were found which were not explained by composition; or, putting it another way, with similar compositions similar properties were obtained. No advantage was found from superheating in the electric furnace, or duplexing of cupola-melted metal.

In order to get low total carbon iron from the cupola, the charge contains at least 60 per cent. steel. Working with cupolas which were not of the most suitable type for the purpose, charges of 70 per cent. steel and 30 per cent. pig have been found to give total carbon around 2.8 per cent. Ferro-manganese additions are preferably made along with the charge. The writer has found very little trouble with manganese distribution when added as ferro-manganese in the charge. The losses are admittedly heavy, generally of the order of 20 to 30 per cent., but they are fairly constant.

Auxiliary Melting Plant and Alloy Additions

Part of the silicon and all the nickel are added in the ladle. If a suitable oil-fired furnace is available near the cupola, it is advantageous to melt the additions and add to the ladle. Not only does this maintain the temperature of the molten iron, but it also eliminates any troubles about distribution. Ordinarily, the silicon is added to the ladle as ferro-silicon, but it is debatable what is the most suitable quality of ferro-silicon to use. The 90 per cent. and over is so light that it tends to remain on the top of the metal, and melt with considerable loss. This is less noticeable with lower grades, but the amount to be melted is correspondingly greater. The 50 per cent. silicon is probably the most commonly used. There are still differences of opinion on the relative proportions of silicon which should be in the charge and in the ladle respectively. Crosby and Herzig[4] recently found that the highest strength was obtained by adding only a quarter of the silicon in the charge and the remaining three-quarters as a late addition. To conserve heat it is desirable to limit the ladle additions, yet the iron from the cupola should be at least mottled, if not quite white. The writer finds 50/50 additions to be a good balance. A little benefit is obtained by heating the ladle additions to redness, but it is only a small proportion of the latent heat of melting.

Tolerances

Some small difficulties may arise on which it is useless to generalise, though it may be helpful to indicate one of these. Irregularity of composition from ladle to ladle can come from uneven melting. This may be due to the ferro-silicon (which is generally in small pieces, or at any rate, is easily broken) finding its way down the cupola more quickly than the charges. It may be due to the pig or scrap melting more quickly than the steel scrap. If the final composition does not turn out as expected, the first line of investigation should be to sample the metal from the cupola before the additions are made; from the resulting analysis it can be determined whether the trouble lies in the cupola practice or in the efficiency of the later additions. The writer has found that iron within the limits of total carbon 2.6 to 2.9, silicon 1.3 to 2.3, and nickel 1.4 to 2.0 per cent., gives an average tensile strength of 24 tons per sq. in. on 1.2-in. bars cast separately. On bars "cast-on" to castings and submitted, while still attached, to a low-temperature stress-relief anneal, the tensile strength has been found to be consistently about 2 tons per sq. in. higher than on separately-cast bars. In regular production many tests exceed 28 tons per sq. in. In castings of varying section the uniformity of iron of this type is excellent. In a casting recently broken up, the heavy sections showed no sign of coarseness, while a wall of metal $\frac{1}{8}$ in. thick (unintentionally produced by shifting of a core) was quite machinable and free from chill. The Brinell hardness of the 1.2-in. bar lies between 260 and 300, yet the castings machine without difficulty.

Low total carbon irons retain their strength well at medium temperatures. Bars from five experimental melts, on a short time test at 450 deg. C., showed an average retention of over 90 per cent. of the room temperature strength.

(*Concluded on page* 450.)

* Metallurgist, G. & J. Weir, Limited. This article is extracted from "Nickel Bulletin."

Use of Electric Welding Plant in the Steel Foundry*

By V. GORDON PEARSON

There are very few people in the foundry industry who are prepared to admit fully of the welding they carry out, and so long as the work is of the hush-hush nature, the best results will never be attained. Although no longer associated with the foundry, the author's interest still remains, since more than twenty years have been spent in the shops. It is the reverse of pleasurable to see foundry work steadily but surely being taken over by the fabricating shops, and it is well known that motors, stators, rotors and bed-plates have been made by the newer process for a number of years, and large and small gear wheels and hydraulic pressure vessels are now being fabricated. Thus there seems to be no end to the possibilities of this construction. It is a personal belief that the home of fabrication should be the foundry, for the following reasons which are considered to be fairly conclusive:—

(1) *Chemical and physical research* is essential to welding, and it is necessary for the chief chemist to work hand-in-glove with the fabricators.

(2) *Heat-treatment* is always good and sometimes essential for fabrication. When all is said and done, welding is another form of casting, and the author is quite sure that no foundryman would dream of sending castings away without stress relieving.

(3) *The machine shop* is an excellent means of preparation and finish of welding.

These three necessities are already in existence in foundries, and, coupled with the fact that the personnel is cradled in steel, the foundry is the ideal place for fabrication to be carried out.

In addition to its use for repairs, the foundry welding plant is an excellent tool for joining to castings such parts as bosses, brackets and flanges, which are a constant source of trouble if cast as an integral portion of the casting, but the welding plant is not used for this purpose as much as it might be. Unfortunately the foundry welding plant is put in some out-of-the-way corner in neglect and shame. It is used improperly as a means of filling rather than as a genuine tool for scientific repair. The work is looked upon with misgiving, and the author considers that foundrymen are to blame by their apathetic manner.

Casting defects are nothing to be ashamed of, and those of the foundry are no worse than in other industries. For instance, the enormous volume of research effected on the plain ingot has failed to cure piping, and, when it is considered how many ingots go to the making of the large casting, there is no wonder that difficulties have to be overcome. Personal experience of steel castings made in many parts of the world lends force to the statement that never on any occasion have people with whom the author has been in contact been able to discard or not use the welding plant. It is an essential unit in the steel foundry and if an executive does not know its possibilities he is not a 100 per cent. foundryman.

Having accused foundrymen of being the cause of foundry welding not being up to standard, it is only fair that reasons for this contention should be given. First of all there is the case of the foreman. The definition of "foreman" is first or chief man, and it is difficult to understand how he can be that if he does not know as much about his trade as the men under him. A works manager would never dream of appointing a fettling-shop foreman over the machine shop, yet probably it would be a wiser course than that he should carry the responsibility of welding. Simply because it is convenient to weld in the fettling shop, the existing foreman is put in charge and, quite often, his ignorance is the cause of much bad work and discontent. Quite recently the author remarked to a welder that there was a new foreman in the shop, and his reply was "that he ought to have an 'L' on his back." No one can object to the fact that a man should go about with an "L" on his back, providing it has not been metaphorically put there by the men. If the foreman has done it, then there is some hope.

One of the most important stages for examination of the casting is during and after preparation, and even if the foreman is fully skilled he has not the time at his disposal to spend amongst his welders. In the interest of the foundry manager it would pay to appoint a special man for the purpose.

Piecework

In some foundries piecework for welders is allowed, and if there is one system which leads to bad practice it is piecework. No one is really capable of setting piecework prices in foundry repair. Recently a man reported that a certain job upon which he had spent three hours was priced at 1s. 6d. Asked how he was going to proportion his money, his answer was that he would look round the fettling shop, find a good one and book part of it on to that. The foremen appear to be afraid of showing the actual cost of the job, and will resort, with the men, to various expedients in order to hide the fact.

Preparation of the Work

Here again, because the foreman is not a welder, he cannot visualise the conditions necessary to carry out the work in the best manner. Preparation is a most important function and is the stage at which critical examination should be made. It is disconcerting to have to state that there are people in the foundry industry who carry out no preparation at all, but weld directly on the top of sand in the belief that it can be floated up whilst the metal is being deposited from the electrode. This statement is hardly credible, but the practice is actually being carried out to-day. Before welding, all bad material must be entirely removed, however much good material has to be sacrificed in the process. The case is similar to that of the dentist, whom no one would thank for filling a tooth unless the groundwork had been thoroughly carried out.

There are many methods of preparation; for example, by the medium of the chipping hammer, machining, oxy-acetylene cutting and carbon arc burning; they all have their different uses, advantages and limitations. In the case of the chipping of a crack by means of the pneumatic hammer, great care should be used to see that the chisel does not become blunt and hide the crack instead of exposing it. Opening up by machining is the best method, but is strictly limited, and a word of warning is called for in reference to the use of the drill. It is satisfactory to use a drill, but the welding operator should not have to weld on the straight walls so formed. The oxy-acetylene cutter is quick, but not particularly clean, and the method most strongly recommended is the carbon arc.

When using this plant, dirt can be followed and cracks traced to their source without the fear of obliteration. What actually happens is that the arc produces a local heat and expansion. It opens up the crack, however minute it may be, and the dust from the carbon will settle therein; its veins will be quite visible when the light is taken away. The appearance is very similar to the case of a magnetic field having been set up and iron powder applied. The carbon arc has sometimes exposed defects of this nature even when acid has failed to find the trouble.

One of the greatest reasons for steel foundry welding being poor and unrecognised is the misuse of the carbon-arc plant. As a welding unit it is a most distinct failure. In many cases the welds are loose because of oxides included; even when they look well, the mechanical properties are extremely poor. The process was introduced to the steel foundry industry some thirty years ago, and the use of it has retarded welding progress very considerably. It is supposed to be a quicker method of repair than that of the metallic-arc process, but here objection can be taken providing large electrodes are used for a comparative test.

Granted serious consideration to the question of foremen, preparation, piecework and the carbon-arc plant, then the level of foundry reclamation work will be raised and receive the recognition of other types of welding.

Inspection

The views of the inspector towards foundry welding are definitely not on a par with their attitude to the same subject in the case of fabrication, and never will be until foundrymen put their house in order. In order to help to build an era of confidence, personal advice is for every foundry manager to interest his local inspectors in the subject and show them how, by scientific control, welding can remove a fault which can be replaced by sound and mechanically strong material. The author has tried the experiment himself and has been rewarded for showing inspectors both good work and bad and how it is produced, and collaborates with them even to-day. If only one foundry puts forward bad work, a great deal of harm is done to the industry. One well-known inspector, asked for his views on foundry welding, merely shook his head and said he did not like it because it was only filling in. Probably this view is a correct one in many instances, but it can be cured.

Testing Welds

One of the essentials of welding is testing. In the best interests of the foundry, the welders should carry out periodical testing. It can be good propaganda. Not only does this keep a check on the electrode manufacturer, but the interest of the operator is stimulated and most valuable data are yielded. It is necessary to know whether the materials being used are suitable for the type of work undertaken. For this purpose a special test is necessary in the form of built-up weld metal to prove soundness and ductility by tensile, bending and impact tests. When the management is satisfied on this point, the testing of the work should take the form of a test which nearest resembles the actual working conditions. In foundry work, there is hardly any case where contractional strain is eased by natural movement—it is nearly all of the locked-up variety. To carry out tests under these conditions it is necessary to fasten the test-pieces so there is no movement and the weld metal has to withstand the contractional strain and then fulfil the specification. Other tests which should be taken are in the form of hydraulic tests and tests to destruction. An indispensable method for visual examination is the use of nitric acid, which every foreman should keep in order to check the operator for penetration and to receive a proper impression of the type of steel upon which he is working. This test is very simply applied and will tell a great deal of the welding story.

Labour Recruitment

The author is often asked to find welders and what constitute the most suitable types. First of all, there is a danger in transferring men from the carbon-arc plant because they have so many

* Paper presented at the joint meeting in London of the Sheffield and London Branches of the Institute of British Foundrymen.

faults to cure. Recently, the author engaged a couple of young men who have spent six months in a government instructional centre, for the purpose of giving them a few hints on steel casting repair. They were both ex-soldiers and knew nothing whatsoever about steel, but they seem to be wonderfully adaptable and will do well, and a personal tribute is due to the instructional centre* for the excellence of their work.

Operators as a whole are really keen on their job, but they are starved for information which they do not obtain because those in authority know a great deal less about the work than they do themselves. Their work cannot be considered to be ended when it has left the welding booth, because the welder should be shown both good and bad work when it reaches the stage of machining or hydraulic testing, and an appeal is made that they be shown the result of the test specimens they make. If the operator be allowed to witness the actual testing and there is something not quite as it should be, the man who has done the work can often give an explanation which otherwise would be difficult to trace. The interest of welding lies in its problems, and there should be somebody in authority who can help the operator to solve them.

Operation of Welding

The one fact which must be known before the weld is commenced is the type of steel to be welded. It is insufficient to place a heap of welding before the man and simply expect him to carry on. Certain types need pre-heating and particular care in welding. The work needs thorough surveying so that it may be carried out in the kindliest manner with a view of minimum distortion.

Repairs are too general to be discussed in detail, but, generally speaking, the work will be opened out to 80 to 90 deg., and it is at this stage that a difference of opinion arises between the foundry foreman and the fettling shop foreman. The foundry foreman sees what he thinks is some trivial defect, and is disgusted when he sees the same article later prepared for welding, and he will go so far as to accuse the man who has carried out the job of finding work for the welder. This type of destructive criticism is useless, but it is recognised that it is prompted by a feeling of dismay. It is impossible to carry out good welding unless the conditions are satisfactory. Penetration has to be secured, and unless the walls are prepared so as to make this possible inferior welds will result. When it is possible to work from both sides it is best to do so, so as to equalise the contractional strain. Where such is not possible a sealing run should be put inside, if it can be got at. Pressure work should always be very carefully inspected inside before preparation commences. The neglect of this duty is found to be the cause of much extra work at a later stage. In the case of a pull at the side of a bracket, a perfect weld can be made, but many people try to weld with the bracket in position and cannot get to the root of the trouble.

It is not pleasant to have to speak of steel foundry welding as it now exists, but many would be in sympathy with this opinion if they had seen the cases of bad work personally encountered. The stigma can be removed in the course of time if foundrymen are prepared for some spade work. The organisation which will help is the Institute of Welding. Many foundries already contribute to their research funds and, if so, why should they not avail themselves of what they have to offer? A great deal of research work is necessary, and it would not be very hard to draw up a programme. No one knows exactly the extent of hardening through the increase in the carbon content of steels. Such information would be a guide for preheating and annealing, and could be tabulated. There is an ever-increasing quantity of different types of alloy steels in the foundry, many of which will have to be welded, and it means finding by experiment the type of electrode to use. One material has an affinity for another and others having the reverse effect. If the Institutes would be prepared to carry out such work, it would give greater confidence in foundry welding and would help to clean up some of the poorer work sometimes encountered.

* The Army Vocational Training Centre at Aldershot does excellent work in this direction.—EDITOR.

DISCUSSION

The CHAIRMAN (Mr. C. C. Booth) said that welding was going to help the foundry industry a good deal, for by its aid the founders were able to turn out a better finished article; but it must be understood that, where it was used, it must be used intelligently. He would have liked to have heard more references in the Paper to the application of welding to cast iron, but he presumed that the same basic principles applied to cast iron as to steel.

Reclamation of Grey Iron Castings

MR. V. C. FAULKNER (Past-President of the Institute) divided welding as applied in the grey iron foundry into two classes, the first as applied to castings which were subjected to inspection, and the second as applied to castings for sale to "the man in the street," for there were striking differences between those two classes. About 90 per cent. of the literature existing on welding as applied to grey iron castings that were subjected to inspection had been written by an author named "Mr. Anonymous"; the moment one looked at the bibliography of the literature on that type of welding, one was impressed by the fact that the actual number of authors was extraordinarily small. It was perfectly obvious that no foundry manager would write of his experiences in the reclamation of castings by welding until he had managed to gain the confidence of the inspectors, as Mr. Pearson had gained their confidence.

On the occasion of the first international welding conference, continued Mr. Faulkner, he had made a great effort to secure a Paper on the subject from a foundry manager, but he had failed; therefore, he had had to write the Paper himself, but he had not been able to secure any real information on the inspected class of welding. On the other class, however, where the castings were bought by "the man in the street," as, for instance, motor-car castings, bath-tubs and so on, information was readily available. The speaker illustrated a typical lay-out of such a department, to indicate that it was managed on a rational basis. The welding department was adjacent to the department which inspected defective castings. Each morning the foreman welder, the metallurgist and the foundry manager held an "inquest" on the castings, and the foreman welder removed to his department the castings which had to be repaired. The castings for repair were divided into two categories, *i.e.*, those of thin section and those of thicker section. The thin sectioned castings were dealt with in a part of the shop where there were series of benches, divided into three sections. In the first of those sections the castings were heated, in the second they were welded, and in the third there was a sand bath in which they could be cooled reasonably slowly. The thicker castings, after heating and welding, were placed in a second furnace and were cooled slowly.

Similarly rational means could be established in the ordinary foundry if the founders could learn from Mr. Pearson how he had managed to secure the confidence of the inspectors. Probably that could be done only by having the maximum of research behind the welding departments and by providing the very best machinery. He had constantly experienced a most unreasonable attitude on the part of inspectors, especially those attached to foreign Governments.

Proper Technique Essential

MR. PEARSON, expressing agreement with Mr. Faulkner's remarks, said the founders would have to come into the open, carry on research, and interest the inspectors in their results. The inspectors would naturally be interested, for they had also to inspect in the fabricating works, and they welcomed any information available. Many of them were taking welding courses. He knew of a foundry at which they had quite openly taken the welding work out of the general routine and had appointed a welding foreman, whose duty it was to supervise both the preparation and the welding, and generally to work in conjunction with the laboratory. On one occasion some welded work was rightly turned down by an inspector because of the appearance of the weld, which had been done by the carbon-arc process; the black oxide ring around the weld was visible, and if it were tapped sufficiently hard it would come out altogether. He had advised the use of the metallic-arc process and the scrapping of the carbon-arc process except for opening up, for which the carbon-arc process was the most important tool. Immediately arrangements were made for the use of the metallic-arc process. Two men from a training centre were taken in and were given an intensive course on repairs. They had been engaged in filling up simple blocks of material and machining them, to ensure that there were no slag inclusions and that the penetration was good. That was the correct type of work for the foundry. The firm in question had always been noted for the quality of its castings, and he was certain that it would be noted for the quality of its welding. It must be realised that castings could not be produced without welding; that being so, a properly qualified foundryman must understand his welding plant as thoroughly as he understood his moulding machines or melting plant. When the founders had reached that stage and were prepared to carry out the best type of work, they could talk on equality with the inspectors and instil universal confidence.

Welding Research

MR. T. R. WALKER, speaking particularly as a member of the Institute of Welding, which had embarked on a most elaborate programme of research, said that the subject of foundry welding ought to be well-ventilated and placed on a scientific basis. The welding of castings should be carried out in conjunction with the inspecting department, provided the inspecting department was adequately equipped.

He asked whether Mr. Pearson would recommend the use of bare electrodes for welding castings, or would prefer covered electrodes. Another question was whether he had any recommendations to make regarding uniform-composition electrodes as against cored electrodes, such as those which contained a core of high-manganese material; the result of using the latter was to increase the manganese content of the weld, which content almost disappeared in ordinary circumstances.

Discussing the training of welders, he asked for Mr. Pearson's opinion of the City and Guilds' course and certificate for welders. He had gathered that a man must carry out something like a dozen welds before he could take the course, and he asked whether Mr. Pearson had had experience of men who had taken the course and whether they were any better for it.

Finally, he pointed out that some pressure castings, such as valves, might leak as the result of having some porous metal inside, and he asked whether Mr. Pearson would recommend welding such a casting on the outside, or scrapping it.

Selection of Rods

MR. PEARSON replied that he had experimented with bare wire electrode and had found it a failure. It would not give the mechanical strength; there was an unreasonable amount of splutter, a loss of arc and an oxidised deposit. In Germany a form of bare wire having a zirconium-filled hole right through the centre was used. The covered electrode had the advantage

of deoxidising, and any particular analysis could be obtained by adding extra rare-metal ingredients in the powdered form, to counteract the loss due to volatilisation. That was particularly noticeable in stainless steels. If there were a loss of chrome, it could be put back in the powdered form in the coating. The covered electrode had many advantages also from the point of view of the operator, for the coating acted as an insulator.

He would not regard the City and Guilds certificate as proof that a man was a competent welder. The certificate was issued mostly to evening students; in the training centres there might be 80 students and only four tables, and a man might get only about a quarter of an hour's practice. The advantage of the course, however, was that the fully-qualified operator gained a knowledge of the theoretical side; he was thus certainly better for the training.

With regard to porosity in valves and other pressure castings, he said most definitely that it was useless plastering a little weld metal on to the outside. The walls of a valve were designed to a certain thickness for a certain purpose. If welding were to be applied, it was necessary to scoop out all the bad or porous metal and weld on a sound base. If the porous metal extended right through the wall, it must be replaced by weld metal. One would probably put a plate inside, and, when the welding was completed, remove the plate by machining on the inside.

Oxy-Acetylene Welding

DR. W. D. JONES commented that Mr. Pearson had dismissed oxy-acetylene welding very briefly by referring to it as dirty, and he would like to know exactly what that meant. Secondly, he understood that some quite interesting results were being obtained in building up worn parts. He asked if there were any future for repair work by spraying, particularly the spraying of cast iron.

MR. PEARSON said that his reference to oxy-acetylene concerned its use for cutting—opening out and preparing for welding—and not for actual welding. If there were a danger of the oxide produced during cutting falling into the hole, oxy-acetylene should be used with caution. Oxy-acetylene cutting was a very quick process, but it was not used very much in foundries. When oxy-acetylene was used there was more danger of warping or cracking than when using other methods.

Metal spraying could not be applied in the steel foundry; it was far too costly, and for general repair he did not think it would be of very much use in the steel foundry. But recently he had watched aluminium sprayed on cast iron, and machined up, and it was an excellent job. In the machining originally a few thousandths of an inch too much had been taken off.

Hard Spots

MR. R. B. TEMPLETON suggested that the foundry foreman had not taken so much interest in welding as he might have done for the reason that his job was to produce good castings, and the sending of castings to be welded was perhaps regarded by him as a reflection on his efficiency. One difficulty with oxy-acetylene welding was that a sort of residual hardness was produced in the weld itself, and a hard spot was formed which could not be machined, with the result that the welded casting was scrapped. He asked whether there was a possibility of ensuring that the hardness of oxy-acetylene welds in castings could be maintained similar to that of the parent metal. Finally, he said he had found that, when using the oxy-acetylene flame for cutting off heavy chunks of metal from castings, as, for instance, when removing risers, the process produced a local hardness which penetrated into the castings, though the depth of penetration might not be more than $\frac{1}{8}$ in.

Welding Cast Iron

MR. PEARSON replied that differences of opinion with regard to welding were not confined to the foundry and fettling shop foremen. A managing director might examine some castings straight from the foundry and feel satisfied that there did not appear to be much the matter with them; but he usually changed his opinion in the welding shop when he saw how much material was being removed from castings. It must be appreciated, however, that when a man was chipping out a crack he must have good clearance for the tool he was using. A crack might have to be $\frac{1}{2}$ in. wide, for the sides must be cut away to enable the electrode to get down to the bottom, and on account of the depth the man must have not less than 80 deg. in which to work as a rule; 60 deg. might be sufficient in the case of a thin plate, however, because there was less depth.

He had not very much hope of reducing the hardness in cast-iron oxy-acetylene welds; there would be considerable hardness around the edge of a weld. One practice was to use Monel metal around the edge, because it was machinable, and to fill in with mild steel. Another expedient was to drill and tap and insert a stud, subsequently cutting off the head. That meant welding on pieces of steel. But it was a failure. In high-test iron one did have a chance. The Institute of Welding was considering research into the welding of cast iron.

Where risers were cut from castings by means of the oxy-acetylene flame, he would expect considerable hardness to be imparted to the castings. That also occurred in steel, if the steel were capable of hardening.

Advice from Welding Authority

MR. A. RAMSAY MOON (Secretary, Institute of Welding) said he had been very pleased to hear that Mr. Pearson was to address members of the Institute of British Foundrymen on welding, because Mr. Pearson always spoke very directly, and in regard to the application of welding in the foundry some direct speaking was necessary. For a long time a great many foundry managers had refused to admit that welding was necessary in their foundries; and some even went so far as to refuse to have a welding plant, so that they could say that no welding was done. The application of welding to both steel and iron castings, however, had come to stay. It was quite unreasonable to scrap a large casting because it had a comparatively small hole if welding could be employed in such a way as to make it fully efficient.

There had been a psychological condition militating against the development of welding in the foundry. Apart from the objections of inspectors and purchasers to castings which were welded, the foundries had lost a certain amount of business owing to the substitution of welded fabrications for castings, and as a result the founders had looked askance at welding and hesitated to bring it out into the light. But surely it was time that welding was accepted by the ironfounder for what it was worth. It could be of very great service, and it should be used where it was sound.

There had, in the past, sometimes been difficulty obtaining good machinable welds, and the reasons for some of the difficulties had not been understood. But a good deal of work had been done, and we were reaching a stage at which we should be able to solve the principal difficulties. The Institute of Welding had a very large programme of research in hand dealing with the weldability of low alloy steels and alloy steels, and the results of this work would be applicable also to cast steels. By linking it up with this work which was in progress, any research undertaken now on cast steel might be expected to produce results in reasonable time.

A project was under consideration for an investigation, in conjunction with the British Cast Iron Research Association, on the welding of cast iron, and a programme had already been suggested covering the principal difficulties in that connection. While the subject was quite difficult, and no complete solution could be expected, if sufficient work could be done to indicate the limits within which welding could safely be applied to cast iron, a great service would have been rendered, and if welding could be brought out into the open so that the buyers of castings would learn that welding could save them money when properly done, it would be of value to ironfounders and purchasers alike.

A vote of thanks was accorded to Mr. Pearson for his Paper, on the proposal of MR. J. E. HURST, seconded by MR. V. C. FAULKNER.

High-Duty Cast Iron

(*Concluded from page 447.*)

Some idea of the stability of very low-carbon nickel-containing cast iron is given in the following figures:—

Electric Furnace: Heat 23.

Total carbon.. ..	2.38 per cent.
Silicon	1.82 ,,
Nickel	1.60 ,,
"As cast"	Tensile strength 28.6 tons.
Treatment	1,000 hrs. at 450 deg. C.
Broken at 450 deg. C.	Tensile strength 22.4 tons.

Electric Furnace: Heat 24.

Total carbon.. ..	2.64 per cent.
Silicon	1.51 ,,
Nickel	1.49 ,,
"As cast"	Tensile strength 29.4 tons.
Treatment	1,000 hrs. at 450 deg. C.
Broken at 450 deg. C.	Tensile strength 23.8 tons.

The foregoing notes refer to certain lines of development only, but it is recognised that there are many others of equal importance and promise. The number of possible combinations of copper, nickel, chromium and molybdenum is immense, and already some irons are being made with as many alloy elements as some of the very high tensile steels.

In considering the applications of high-strength irons, it is well to bear in mind that, although the tensile strength and impact resistance are greater than in the older types of iron, the material is still cast iron and has no measurable ductility. It contains graphite, and although it may be in smaller flakes, yet the iron will not bend appreciably. This remark applies to "as-cast" material and not to heat-treated crankshafts, etc., made of what is virtually a high carbon steel. There are, however, in engineering, many fields of usefulness for irons of over 20 tons per sq. in. They help to meet the conditions of higher pressures, speeds and temperatures encountered in the general desire for higher output from existing designs.

REFERENCES.

[1] MacPherran, R. S.—"Cupola High-Test Cast Iron." Trans. A.F.A., 1937. Vol. 8. Pp. 343-349.
[2] British Standard Specification 786, 1938.
[3] MacDougall, B.—"High-Duty Iron. Some Experiments with the Rocking Arc Furnace." FOUNDRY TRADE JOURNAL, 1937. Vol. 57. Pp. 407-412.
[4] Crosby, V. A. and Herzig, A. J.—"Late Additions of Silicon to Cast Iron." "Foundry," 1938. Vol. 66. Pp. 28-29 and 73.

Publication Received

The International Mercantile Diary and Year Book, 1939. Published by Syren & Shipping, Limited, 44 & 46, Leadenhall Street, London, E.C.3. Price 12s. 6d.

This book is a combination of a complete economic geography book (replete with essential information necessary to any concern undertaking an export business), a diary and a ready reckoner. Measuring about 9½ in. × 7 in., the volume gives ample space for notes in its diary section, whilst the matter given within the section headed "General Information" has been well chosen and includes conversion tables not readily found elsewhere. At the published price it is excellent value for money.

The Powder Metallurgy of Iron

DISCUSSION OF DR. W. D. JONES'S PAPER

Dr. W. D. Jones's Paper on "The Powder Metallurgy of Cast Iron, with Particular Reference to Pacteron," read before a joint meeting of the London and Sheffield Branches of the Institute of British Foundrymen, disclosed a unique piece of research work, but was really inadequately discussed on account of its novelty. The time factor will have to operate before its true applicability to industry can be assessed, although the theoretical aspect received full approbation. The Paper was reproduced in the JOURNAL for December 1.

The discussion was opened by MR. V. C. FAULKNER (Past-President of the Institute), who commented that Dr. Jones had selected the smallest size of powder resulting from the preparation of chilled-iron shot, and drew attention to the potentialities of ordinary iron borings. These were already fairly small, and they could be reduced very easily to fine powder, and he suggested that commercially they presented a more interesting field for investigation than did the powder from chilled-iron shot.

Inasmuch as Dr. Jones had put forward some very interesting results based on his theory that the phosphide eutectic was the cementing material, Mr. Faulkner suggested that experiments might be made in the use of lead, because there was no question of the normal alloying.

An omission from the Paper concerned pressure. It was suggested that low pressures would give the desired results, and there were some speculative remarks in the Paper about standardising on 8 tons per sq. in., but one would like to know what would happen if pressures of 20 tons per sq. in. or more were used. The maximum potential strength of cast iron was probably of the order of 60 tons per sq. in., and one wondered whether, by using higher pressures, still higher tensile could be reached.

The Institute must be indebted to Dr. Jones for having chosen it as the medium through which to put forward what was unquestionably an unique line of research.

The Drawback of Graphite

DR. JONES replied that he had conducted experiments in the use of powder from cast-iron borings, but he had experienced difficulty due to the graphite. Apparently, free graphite entirely prevented the consolidation of powder, but he imagined there were means of eliminating the graphite. At low temperatures, for example, the inclusion of an oxidant to oxidise the graphite seemed to be partially effective. But the result normally obtained when using borings at high temperatures was an extremely porous mass having little or no tensile strength, and so far he had not found any other material which was really so satisfactory as the white cast-iron grit.

The suggested use of lead as a bond had not occurred to him, but he felt that probably it would not be effective.

One reason why he had chosen a pressure of 8 tons per sq. in. was that he could not have found moulds which would have stood up well at higher pressures. He had obtained consistently good results at 8 tons, and occasionally he had obtained good results at pressures as low as 1 ton per sq. in.; that had led him to suggest that low pressures would be effective. He imagined that very high pressures would prove ineffective, even if he could find dies strong enough to withstand those pressures. In the process one was, in fact, using a small amount of liquid, and if excessively high pressures were used, the liquid would be squeezed out. In the composition of other metal powders—copper, iron, nickel and one or two other metals—it had been found that the use of excessively high pressures gave very bad results. Strange as it might seem, there was an optimum pressure, on either side of which porosity was produced.

Sphere of Powder Metallurgy

MR. S. V. WILLIAMS, B.Sc., emphasised particularly that powder metallurgy was of the greatest importance in cases where articles could not be made by the conventional casting methods. One or two well-known examples had been given in the Paper, and there were many others, particularly in the electrical industry, one of the best known being the production of tungsten filaments for lamps, which production was considerably advanced by the development of powder technique.

Distinction should be drawn between the two powder processes. One process was to press a powder and sinter it, in order to produce a metal which was different from the ordinary solid mass in respect of density and mechanical properties; the other was to press a powder at temperature, in the manner in which Dr. Jones had pressed iron powder. The figures given for platinum, at the beginning of the Paper, were typical. By simply pressing and sintering the powder, one did not develop the product with the full density, but with a density 3 or 4 points below the maximum; the material had to be mechanically worked before the full density and mechanical strength were attained. On the other hand, if the metal powder was pressed hot, the forging and pressing operations were combined. But there was an important exception where there was a liquid phase present, as in the G.E.C. heavy alloy. That alloy consisted of 90 per cent. tungsten, with nickel and copper, and if produced under proper conditions, its tensile strength was between 40 and 50 tons per sq. in.

The experience of himself and his colleagues would confirm Dr. Jones's theory that the phosphide eutectic was responsible for the bonding and the increase of strength, for they had found that they did not produce an alloy of high strength unless the sintering were carried out at a temperature above that at which the liquid melted; under the latter conditions there was a very rapid improvement in mechanical properties, as indicated in Fig. 4 of the Paper. But they did not heat the material under pressure; they compressed the mass, and then heated it in the case of the G.E.C. heavy alloy to a temperature above that at which the copper-nickel-tungsten phase would melt.

Discussing methods of heating, he mentioned a method in operation in Germany whereby the material was heated in graphite moulds electrically by induction; in other words, the material was heated by heating the mould, and he had been surprised that the moulds had stood up to the pressure used.

On the general problem of powder metallurgy, Mr. Williams confessed that he was still very doubtful whether there was any real field for the production by such means of alloys or metals which could be produced by conventional methods; in other words, he regarded the powder technique as being applicable only to the production of specialised products which could not be produced by other means. Figures given in the Paper with regard to iron were very interesting, and quite surprising, but he asked whether Dr. Jones visualised the production of complicated shapes by powder technique, or whether its use was confined to the production of bars or plates, and the like. He could not imagine that the process would be of very much use unless it could produce intricate shapes which were difficult to cast. In the permanent magnet field the materials used were mainly cast, but certain shapes were difficult to cast, and possibly powder metallurgy processes might be of some use in that field. He had also in mind, not only the expense of intricate moulds, but also the troubles arising from the uneven distribution of the pressure in the moulds, *i.e.*, failure to distribute the pressure uniformly in the corners, and so on.

DR. JONES replied that obviously, when using a pressing technique, one was limited to the production of shapes which could be pressed. At the same time, there were complicated shapes which could be so formed, but which, if produced by casting, would involve the use of very intricate machinery.

Heating Conditions

MR. E. H. BROWN asked for information concerning the sintering temperature, and whether the heating could be practically instantaneous or whether the material required soaking under heat. Commenting on the search for extremely high strength alloys for use in bearings, he said he had been given to understand that there was an enormous field for a particular nickel-iron bearing, if it could be produced.

DR. JONES said that sintering was probably effected within a few seconds; but, of course, sufficient time must be allowed for the actual movement and consolidation of the particles. He had not heard of the nickel-iron bearings but there was a very active search for stronger bearings, and many alloys were under consideration.

MR. T. R. WALKER (Hon. Secretary and Vice-President of the Sheffield Branch) recalled that in Germany he had seen the manufacture of bearings consisting of a mixture of steel and copper, the copper being added more or less in the form of filings or turnings, and not in the form of powder. The specific reason for adding the copper in that way was to produce a porous structure. Some of the bearings were in use on the German railways. Owing to their porosity, they could be lubricated very effectively; further, if the oil pressure were increased, a very effective brake could be applied.

A Historical Invention

MR. J. E. HURST (Past-President, Institute of British Foundrymen) said he supposed it was appreciated generally that powder metallurgy was an established section of the metallurgical industries to-day, and we were indebted to Dr. Jones for having made that clear in the book he had published recently. The application of the principles of powder metallurgy to cast iron interested Mr. Hurst greatly, and at the risk of being considered over-enthusiastic he said it appeared to him that the occasion of the presentation of Dr. Jones's Paper was epoch-making in the history of cast-iron metallurgy. He imagined that Dr. Jones, as the result of his experimental work in connection with cast-iron powder metallurgy, had introduced a really new discovery, and a very important one. It seemed a great pity that the announcement of so important a discovery should not have had the benefit of wider publicity in the Institute, and he would have liked the Paper to have been presented before a much larger audience than was represented at that particular meeting. Inasmuch as an international conference was to be held next June in this country, which would be attended by representatives from all the countries in the world that were interested in cast iron, he suggested that it might be possible to persuade Dr. Jones to read his Paper again, or perhaps an extended version of it, on that occasion, for it would show the world that cast-iron metallurgists in this country were still doing something to further the usefulness of cast iron. From time to time in the history of ironfoundry metallurgy it had been prophesied that soon cast iron would have no further usefulness. The introduction of welded structures, the development of the bakelite industries, and so on, had been mentioned as reasons for regarding cast iron as being in a stage of decline. But each time something new arose and cast iron maintained its position in the metallurgical industry. Those

new things arose from totally unexpected quarters, and the development recorded in Dr. Jones's Paper was another example.

Small Pressings

Commenting upon the doubts expressed by Mr. Williams as to the utility of the process being limited to specialised jobs, Mr. Hurst said that recently he had seen a very simple job which was made in America with either cast-iron or steel powders. It was a small part produced by repetition methods and was used in thousands in the construction of a mass-produced machine. The Americans, who were very interested in developing mass-production methods, regarded it as very much cheaper to produce that article by compressing powder than to machine it from a bar, even when using a fully automatic tool, bearing in mind the time occupied in the machining and the losses in turnings and borings. By the powder process it was produced sufficiently accurately. He was informed that cast-iron powder compressed in the manner described by Dr. Jones would meet the requirements of that part satisfactorily, and the American example served to show the possibilities of the process, from the point of view of the mass production of very simple parts.

Finally, he asked for information as to the value of hydrogen-reduced powders, whether or not they possessed any intrinsic disadvantage. Hydrogen-reduced powders, so far as pure iron was concerned, were very well known, and it seemed to him that they were easily produced.

Influence of Hydrogen

DR. JONES said that Mr. Hurst was undoubtedly right in the view that a surprisingly large number of parts could be made by the powder technique. With regard to hydrogen-reduced powders, he said their principal defect was the tendency to loss of carbon in the production of the powders; it was difficult to produce iron powders with controlled amounts of carbon. The carbonyl process would give carbon-containing powders. But with neither of those powders could one obtain the same tensile strength as with the cast-iron grit described in the Paper.

MR. HURST said he had wondered whether the absorption of hydrogen would be a fundamental difficulty.

DR. JONES replied that, in his opinion, if there were a marked absorption of hydrogen it would be of advantage. One of the chief advantages of the carbonyl process was that it afforded the possibility of obtaining a controlled carbon content.

Magnet Trade

DR. A. B. EVEREST (Past-President of the London Branch) joined in the appreciation of Dr. Jones's Paper, but expressed some doubt as to how far the new process of powder metallurgy would be of value to the industry, because obviously a pressing in cast iron must compete with a casting, and it would only compete successfully if it were cheaper or better. For small parts there seemed to be possibilities in pressings made from powder, and one could visualise the production by that means of small and simple shapes having special properties; but he foresaw a great deal of difficulty in producing by that means products of complicated shape such as were produced in the ordinary foundry.

Commenting on Mr. Williams's reference to the making of some of the new magnets by powdered metals, Dr. Everest emphasised that those magnet alloys were extremely difficult to cast, and that when they were cast they were quite unmachinable. The machining problem was of very great importance in connection with magnets. No true comparison therefore existed between the application of powder in this case, and products made from cast iron.

Dr. Everest recalled a statement he had made (in the discussion on Mr. Hurst's recent Paper to the London Branch on "What we do not Know about Cast Iron") to the effect that one of the most important future developments in cast iron was likely to be in the direction of annealing white iron castings. In that connection he said that Dr. Jones had shown that remarkable strengths could be attained in parts which were produced from a white iron powder, and had confirmed by his work that extraordinary properties could be produced in white iron in the annealed condition.

DR. JONES drew attention to his reference, at the end of the Paper, to the possibility of obtaining better magnet alloys. He believed magnets had been made by sintering mixtures of various metals—nickel, iron, cobalt, and so on—and that one could obtain those various metals in powdered form and start with a mixture of the various powders, or alternatively, which would probably be better, commence with the powdered alloy. Powdered alloys of this type were now available.

Influence of Particle Size

MR. WALKER said that his firm manufactured cast magnets; in his office he had some magnets made from powder, but he did not fear much competition from them. They had an extremely high coercive force, but their remanence and maximum induction were much lower than in the cast magnets, as would be expected.

Where the particles were uniform spheres, the porosity of the finished article was fairly constant. Having examined chilled shot under the microscope, he said that the bigger particles were really spherical, but as the size of the particles was reduced they became less spherical. He asked whether Dr. Jones had altered the grading of his original mixture, because by suitable adjustment of the grading one could reduce the porosity to a very low figure, and by uniform grading one could obtain a higher porosity. That was a matter of interest in experiments, because it meant that one could govern the amount of space into which the liquid phase was able to penetrate.

DR. JONES agreed that particle size had a great and important influence, and said that the powder used in the course of his research had consisted entirely of angular particles. He believed that some of the magnet steels consisted of pressed powders bonded with Bakelite.

MR. WALKER said that those he was referring to were pressed and sintered.

The CHAIRMAN (Mr. C. C. Booth, J.P.) commented that, as the result of research, the foundry industry was progressing rather than receding. Only recently, if a foundry unexpectedly made an extremely good batch of castings, they were unable to reproduce the conditions because of lack of scientific control. Research had undoubtedly extended the boundaries for the usefulness of cast iron, by providing higher strength materials and other controlled physical properties.

On the proposition of MR. J. E. HURST, seconded by MR. V. C. FAULKNER, a very cordial vote of thanks was accorded to the author.

Imported Electric-Furnace Pig-Iron

The Treasury, on the recommendation of the Import Duties Advisory Committee, have made the Import Duties (Exemptions) (No. 6) Order, 1938, which provides for the addition to the free list as from December 8 of pig-iron produced in an electric furnace and containing not more than 0.025 per cent. by weight of phosphorus, not more than 0.02 per cent. by weight of sulphur and not more than 2.5 per cent. by weight of total carbon. A White Paper containing the Treasury Order and the Advisory Committee's report is published by the Stationery Office.

LORD SEMPILL, Deputy-President of the Institution of Production Engineers, speaking at Loughborough recently, made a statement that a new research laboratory in production engineering would be set up at Loughborough next year. He thought it would not be long before a national certificate for production engineering became part of the Board of Education scheme for national certificates.

The Late Mr. E. Ronceray

Last week we announced the death of Mr. E. Ronceray, the chairman and managing director of the Bonvillain & Ronceray Company, of Choisy-le-Roi, near Paris, manufacturers of foundry equipment. Mr. Ronceray was in his 70th year and leaves a widow and one son, Mr. Robert Ronceray, who (as we reported a week or two ago) is to assume control of the works on January 1 next year. Few people were better known in international foundry circles than was Mr. Ronceray, due in some measure to his outstanding ability as a linguist. He has lectured in both Great Britain and America. To most foundrymen his name is associated with the "pencil runners" type of gating, yet only a few weeks ago he wrote to deny any claim to their invention, which he ascribed to a Mr. Saillot. Yet it was his work which popularised the system internationally. Mr. Ronceray had no hobbies, unless the training of young foundrymen could be so described, for with his creation of the Paris Foundry High School he found an outlet for his abundant mental energy. Holidays and week-ends were sacrificed over a long period for the well-being of the students. He presided over the Association Technique de Fonderie with such distinction that he was made a life-president. His work for education brought him the decoration of officer of the Legion of Honour, whilst the Institute of British Foundrymen recognised his technical achievements by electing him an honorary member in 1922; he had been a member since 1909, and honorary corresponding member of the Council for France since the inception of this system of representation. He was honoured by the American Foundrymen's Association by the award of the Whiting Gold Medal and honorary membership. He was also awarded an honorary membership in the Czecho-Slovakia Foundrymen's Association. The name of Ronceray will go down in foundry history as that of a pioneer of the now well-established technical co-operation amongst foundrymen of all nations.

MR. E. RONCERAY.

National Institute of Industrial Psychology

The Annual Report of this Association leaves one bewildered. Most people imagine that the main activity of the Institute is the fitting of round or square pegs into circular or carriform holes, but few realise that "the Institute assisted in estimating the potential market for a group of products and the company's share of this market" or "a study was made of the sales methods of a firm of flour millers," or again "to increase accuracy in planning to facilitate the handling of urgent orders." The mental make-up of the reviewer is such that he is unable to comprehend just what the boundaries of industrial psychology should embrace. He feels that already they are too extensive, due no doubt to the fact that when basic principles have been established and enumerated there is little left for the experts to do, except in the field of application of these rules. Yet paradoxically, if the primary job has been well done, applications should surely be left in the hands of those people who either by tuition or nature fully realise their import.

Since 1788

"STANTON"

BRAND OF

PIG IRON

150 Years of Service in the Engineering Industry

For 150 years "Stanton" brand of pig iron has been extensively used by many famous companies in the engineering industry, and its popularity is continually increasing.

"Stanton" brand has distinct characteristics of its own, in the same way as other well-known brands of foundry pig iron (for example "Holwell" and "Rixon's") also produced by the Stanton Company, and all of which are specially suitable for the production of high grade castings including machinery components, bed plates, flywheels, etc.

The Stanton Company have many years' experience of metallurgical problems. This experience is at your disposal on any problem in connection with the Foundry.

THE STANTON IRONWORKS COMPANY LIMITED
Near NOTTINGHAM

The Largest Producers of Foundry Pig Iron (for Sale) in Great Britain

The Week's News in Brief

Trade Talk

ABOUT 150 PEOPLE attended the annual staff dance of Ruston & Hornsby, Limited, held in the George Hotel, Grantham.

EMPLOYEES OF G. & J. Weir, Limited, of Cathcart, Glasgow, have formed a works orchestra. At the moment there are 24 players.

THE SUMMER MEETING of the Institution of Mechanical Engineers next year will be held in New York from September 5 to 8.

THE NEW IRISH STEELWORKS at present under construction at Haul Bowline, County Cork, will begin production in the spring.

AN ORDER for 30 locomotives placed with the North British Locomotive Company, Limited, Springburn, Glasgow, in September, has now been increased by an additional ten locomotives. These are chiefly for use on some of the lighter branch railway lines in New Zealand, in pursuance of the Government's railway development scheme.

THE DIRECTORS of Petters, Limited, propose to change the name of the company to the Associated British Engineering Company, Limited. It is stated that certain other holdings in engineering companies have been, or are in process of being acquired, and that it is the intention of the board where possible to continue the policy of consolidating the production and sale of oil engines.

PORT ELIZABETH, South Africa, has placed a contract for 77 miles of large-diameter steel pipes in Great Britain. The value of the order is in the neighbourhood of £500,000, and the contract has been taken jointly by Stewarts and Lloyds, Limited, and the South Durham Steel & Iron Company, Limited. The pipes will be manufactured in the West of Scotland and North-East of England, in roughly equal proportions.

SPEAKING AT the annual general meeting of R. A. Lister & Company, Limited, yesterday, Mr. Percy Lister (chairman) said the new mechanised foundry at Dursley had been in operation for the major portion of the year under review, and was giving results that fully justified the substantial expenditure on it. A duplicate equipment was being installed which would enable the foundry to double the output early in the new year.

THE FIRST 40,000-kw., 3,000-r.p.m. steam turbine to be supplied for this country is now under construction by the English Electric Company, Limited, to the order of the Yorkshire Electric Power Company. The pressure under which it will work is 650 lbs. per sq. in., and the total temperature 470 deg. C. The high-pressure casing for the turbine is formed of two half nosing castings, made from a special alloy steel by Edgar Allen & Company, Limited. The complete half nosing has a total weight of 7 tons 17 cwts. The length is approximately 6 ft. 6 in., and the width approximately 5 ft. 6 in.

A LOSS of £12,420 on the year's trading was reported at the second annual general meeting at Waterford of Allied Ironfounders (Ireland), Limited. The chairman, Mr. R. J. Hearne, said that while the position was still such as to give the directors grave anxiety, he felt that the company was nearing the turning point, and if recent progress continued, the results for the year should prove more encouraging. Returns for the present year showed a marked improvement. By the unanimous resolution of shareholders it was decided to exclude the Press representatives from the discussion on the chairman's address and the directors' report and balance sheet. Reporters were informed later that, after prolonged discussion, the shareholders expressed themselves satisfied with the explanations given by the board of directors.

Personal

MR. C. GILBERT SMITH, of Norton Motors, Limited, Birmingham, has been elected President of the British Cycle & Motor Cycle Manufacturers' and Traders' Union.

MR. W. E. DOUTHWAITE and Mr. James Hogg have joined the board of the Burntisland Shipbuilding Company, Limited, while Mr. H. Johnson has resigned his position as shipyard manager and director.

MR. J. HEPBURN, at present a director and secretary of the J.P. Tubular Heater Company, Limited, Newarthill, has been appointed commercial manager of Davidson & Company, Limited, Sirocco Engineering Works, Belfast. He will assume his new post early in the New Year.

MR. KENNETH M'DONALD, who served his apprenticeship with Wm. Denny Bros., Limited, Dumbarton, and has been with the L.N.E.R. for the past seven years, has been appointed Inspector of Works with the Colonial Government for the Nigerian Railways.

Wills

HALL, G. H., of Darton, Barnsley, retired engineer and ironfounder ... £6,829

SCOTT, W. H., of Thorpe St. Andrews, Norfolk, chairman and managing director of Laurence Scott & Electromotors, Limited £82,949

Obituary

MR. JAMES SNEDDON, a patternmaker, had a seizure whilst at work at the Sunnyside Iron Works, Falkirk, on December 9, and died almost immediately.

COL. JOHN IZON CHESSHIRE died last week at the age of 59. Col. Chesshire was chairman and managing director of Izons & Company, Limited, West Bromwich, hollow-ware manufacturers, and founder of the Albion Foundry, Tipton. He was the fifth direct descendant of the founder of Izons & Company, the firm having been founded in 1763.

Contracts Open

Abergarw, December 19.—Provision and laying of 105 yds. of 14 in. dia. cast-iron pipes, for the Mid-Glamorgan Water Board. Thomas & Morgan & Partners, civil engineers, Pontypridd. (Fee £1 1s., returnable.)

Belfast, December 19.—12,000 yds. of spun-iron pipes in diameters from 3 in. to 6 in., for the Belfast City and District Water Commissioners. Mr. W. I. Quinn, secretary, Water Office, Belfast.

Dublin, December 21.—Provision and laying of water mains, for the Commissioners of Public Works. Mr. G. P. Fagan, secretary, Office of Public Works, Dublin. (Fee £1, returnable.)

Rugby, December 17.—857 yds. of 4 in. dia. spun-iron pipes, together with cast-iron specials, for the Rugby Rural District Council. Mr. W. E. B. Bunker, engineer, 24, Warwick Street, Rugby.

Worcester, December 31.—Iron castings, mild steel, etc., during the year ending March 31, 1940, for the Highways and Bridges Committee of the County Council. Mr. B. C. Hammond, county surveyor, County Buildings, Worcester.

Company Reports

John Harper & Company, Limited.—Interim dividend of 3 per cent.

Revo Electric Company, Limited.—Interim dividend of 5 per cent.

Greenwood & Batley, Limited.—Interim ordinary dividend of 3 per cent.

Electric Furnace Company, Limited.—Interim dividend of 2½ per cent.

Boulton & Paul, Limited.—Dividend of 10 per cent. on the ordinary shares for the year to September 30.

Laurence, Scott & Electromotors, Limited.—Dividend on the cumulative redeemable preference shares for the period July 1 to December 31.

Cannon Iron Foundries, Limited.—Dividend on the 5½ per cent. redeemable cumulative preference shares for the half year ending December 31, 1938. No dividend on the ordinary shares.

F. H. Lloyd & Company, Limited.—Interim dividends for the half-year ended September 30 of 2½ per cent. on the 5 per cent. cumulative preference shares and 3 per cent. on the ordinary shares.

New Companies

(From the Register compiled by Jordan & Sons, Limited, Company Registration Agents, 116 to 118, Chancery Lane, London, W.C.2.)

O. J. Wootton, Limited, 69, Temple Street, Wolverhampton.—Capital £3,000. Brass and aluminium founders. Directors: O. J., O. J. G. and M. S. A. Wootton.

Dartmouth Manufacturing Company, Limited, 27, Trinity Road, West Bromwich, Staffs.—Capital £20,000. Manufacturers of range and other boilers, metal furniture, etc. Directors: H. A. Harris and A. Buswell.

Forthcoming Events

DECEMBER 16.

Institution of Mechanical Engineers:—First Report of the Research Committee on High-Duty Cast Irons for General Engineering Purposes, presented by J. G. Pearce, M.Sc., at the Institution, Storey's Gate, London, S.W.1, at 6 p.m.

DECEMBER 19.

Cleveland Institution of Engineers:—Joint meeting with members of the Iron and Steel Institute resident in Middlesbrough district. "Practice at the Works of the South Durham Steel & Iron Company, Limited, and Cargo Fleet Iron Company, Limited," Paper by James Winter, at Cleveland Scientific and Technical Institute, Middlesbrough, at 7.30 p.m.

DECEMBER 21.

Institute of Welding:—"Welding of German High-Tensile Steels," Paper by Prof. Dr.-Ing. E. H. Schulz, at the Institution of Mechanical Engineers, Storey's Gate, London, S.W.1, at 6.30 p.m.

Institute of British Foundrymen

DECEMBER 16.

London Branch:—Annual dinner and dance, at Criterion Restaurant, Piccadilly Circus, W.1, at 7 p.m.

DECEMBER 19.

Falkirk Section:—"Alloy Cast Irons," Paper by T. Shanks, at Temperance Café, Lint Riggs, Falkirk, at 7.15 p.m.

Making a Large Lathe Bed

(*Concluded from page* 444.)

small dirt traps shown in the sketch probably did not do much good, but were an old-established practice which he had not attempted to alter.

Final Straightness

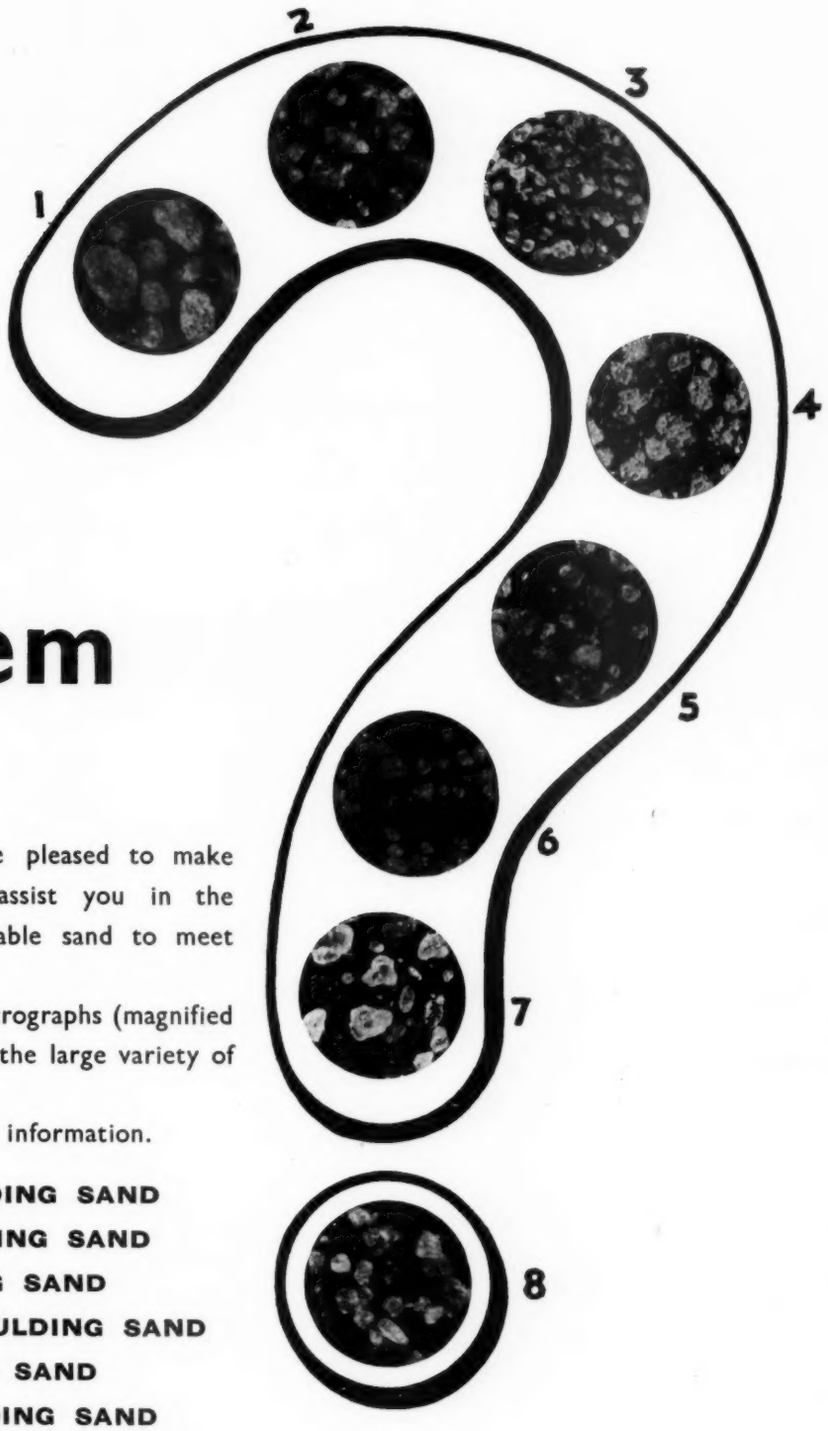
MR. HURST was specially interested in the methods Mr. Buchanan had adopted to ensure that the beds would be straight. His experience was that, after rough machining, there was a tendency for the casting to distort, due to the release of casting strains; accordingly, he thought it necessary to leave such castings to season for some time before final machining.

MR. BUCHANAN said the method of preventing side camber on this casting was new as far as he was aware; it was unorthodox but completely successful. The castings were still rather warm when taken to the dressing shop; in fact, ⅜ in. of camber came out actually during cooling. In all cases referred to, the castings were straight when cold, and no signs of twisting were observed on rough machining. Also, the castings referred to were in the shops over a year before despatch, and often over 7 months before commencing to assemble the machine with the present rate of production in the foundry.

MR. BALLANTINE (Branch-President) congratulated Mr. Buchanan on the excellent Paper he had submitted, and expressed the most sincere thanks and appreciation of the members. Referring to the model lathe-bed pattern, he remarked the design of the cross webs seemed to him to be poor.

MR. BUCHANAN said that triangular-shaped cores were more troublesome than square cores, but there was no doubt of the marked superiority of the diagonal design, and the extra trouble in making was in the end amply justified. He concluded by saying that he was indebted to John Lang & Son for permission to put this Paper before them.

Have you a sand problem



Our Technical Staff will be pleased to make recommendations and to assist you in the selection of the most suitable sand to meet your exact requirements.

The accompanying photo-micrographs (magnified 25 diameters) show eight of the large variety of sands which we produce.

Please write us for detailed information.

1. YORKSHIRE MOULDING SAND
2. BRAMCOTE MOULDING SAND
3. THANET MOULDING SAND
4. YORK YELLOW MOULDING SAND
5. ZENITH MOULDING SAND
6. MANSFIELD MOULDING SAND
7. CAVE BROWN MOULDING SAND
8. No. 60 MOULDING SAND

Please write for full particulars to:—

GENERAL REFRACTORIES Ltd.

Telephone: Sheffield 31113 (6 *lines*). **GENEFAX HOUSE, SHEFFIELD, 10** *Telegrams: "Genefax, Sheffield."*

Raw Material Markets

It was announced on Saturday that the British Iron and Steel Federation, with the concurrence of the Import Duties Advisory Committee, had decided to reduce iron and steel prices as from January 1. The new prices thus established will hold until June 30, 1939, subject to the proviso in all sales and contracts that deliveries after the latter date will be at the Association prices then ruling. The price reductions in the chief products are as follow:—Pig-iron: Basic, 7s. 6d. a ton; hematite, 12s. 6d. a ton (plus reduced extras). Heavy-steel products: Plates (heavy, medium and chequered), 17s. 6d. a ton; joists and sections, 12s. 6d. a ton. Rails (heavy), 12s. 6d. a ton. Semi-finished steel: Soft basic billets, blooms and slabs for re-rolling, untested, 10s. a ton; tested, 15s. a ton; forging billets, blooms and slabs, basic, 12s. 6d. a ton; sheet and tinplate bars, 10s. a ton. Rolled and re-rolled products: Merchant bars, sections, hoop and strip, basic, untested, 12s. a ton; tested, 18s. a ton. Sheets: Black, £1 a ton; galvanised, £1 5s. a ton.

This announcement with regard to iron and steel prices for delivery in the New Year will be generally welcomed, as it provides a firm basis for forward business, but makers of foundry pig-iron have still to fix their quotations. Meanwhile, new business is negligible, but it is expected that consumers will release orders on a good scale when the new prices are made known.

Pig-Iron

MIDDLESBROUGH.—The continued delay in the publication of prices of foundry pig-iron for delivery in the New Year is regretted in the Cleveland area. No new business has been transacted during the past week. Makers' stocks are heavy and will be sufficient to meet the demand, at any rate for the early part of next year, even if consumers place orders on a good scale. Although there has been very little call for deliveries of hematite recently, it is believed that consumers are now much better employed than they have been over the past few months. The reduction of 12s. 6d. per ton in the price of hematite, to take effect as from January 1, has caused some disappointment in this area, where it was hoped that prices would be lowered by about 20s. per ton. However, now that it is known what quotations will rule after the turn of the year, it is expected that consumers will take up larger tonnages and producers will welcome the opportunity to reduce their heavy stocks. The new quotation for East Coast mixed numbers will be 120s. per ton.

LANCASHIRE.—Producers are easily able to meet the current demand for foundry iron, which is confined to small tonnages for prompt delivery. The number of small parcels being called for would seem to indicate that many consumers have about cleared their stocks and will be in the position to enter into forward contracts when the new prices are announced. For delivery to users in the Lancashire price zone, offers of Derbyshire and Staffordshire brands of No. 3 foundry iron for delivery between now and the end of the year are on the basis of 114s., less 5s. rebate, with Northamptonshire No. 3 at 112s. 6d. and Derbyshire forge iron at 111s. to 113s., according to the class of user. The hematite trade continues to be quiet, but there may be some improvement now that lower quotations are announced, although most users are well covered ahead. West Coast mixed numbers for delivery equal to Manchester after the end of the year are quoted at 128s. 6d. and East Coast at 128s.

MIDLANDS.—Pending an announcement with regard to future prices of high-phosphorus iron, there is little or no new business in the market. Most consumers are not too well employed, and there is unlikely to be any rush for supplies in the New Year. A steady demand continues to be received for low-phosphorus iron. Makers of this type of iron have reduced their prices during the year, and so it is not expected that there will be any further reduction of a substantial nature in the New Year. The existing rates vary between £5 10s. and £6 10s. per ton. Most consumers of hematite are still well contracted for supplies, and the publication of the new prices is not expected to make much change in the situation. Quotations will be lowered by 12s. 6d. per ton. Substantial stocks are on hand at the furnaces, but, as output is low, these are being gradually cleared.

SCOTLAND.—Although lower prices for delivery after the end of the year have been announced for basic pig-iron, no announcement has as yet been forthcoming with regard to foundry iron. Business is negligible, but an expansion is expected when consumers are given a firm basis on which to negotiate. The light-castings founders continue to be poorly employed. Although no shipments of pig-iron were despatched from the Tees to Scotland in November, a small cargo was last week sent to Leith. Now that the new steel prices have been published, an increase in business for steel-making pig-iron may be anticipated. The new quotations for steel-making iron are as follow:—120s. 6d. for hematite mixed numbers; 100s. for Scottish basic; and 92s. 6d. for English and Indian basic, all delivered f.o.t. steelworks here.

Coke

A further reduction has taken place in the amount of new business in foundry coke, due, no doubt, to the fact that prices have been fixed at minimum levels up to the end of June next. As yet, most consumers are not covered beyond the end of the first quarter, while some users have not gone beyond December 31, and will again be in the market in the early part of the year.

Steel

The announcement of the new prices for the first six months of 1939 has been favourably received by the market. Although it is yet too early to see the effect the reductions will have in stimulating business, it is realised that, taking into consideration the present costs, the steelmakers have gone as far as could be expected to meet consumers. The demand for semi-finished steel continues to broaden, and should be helped by the price reductions. While some firms still hold substantial stocks, a fair volume of business has been placed with British producing works, most of which have improved their position. Business in the finished-steel section of the market shows signs of improving, and following the announcement of the new prices, a considerable volume of inquiry developed. The producing works, however, are not well employed, and for the time being are able to give quick delivery. Most of the business is still of a hand-to-mouth character, but some of the inquiry circulating is for delivery well into 1939.

Scrap

For delivery over the first half of 1939, prices of heavy-steel scrap have been reduced by 8s. 6d. per ton. This move will be generally welcomed and should pave the way for an expansion of trade, which recently has been quiet. Merchants' stocks are high and consumers' contract deliveries are easily met without delay. Most foundries are covered for supplies of cast-iron scrap, but consumption is fairly good.

Metals

Copper.—Following the announcement in the middle of last week that copper producers operating under the restriction scheme had decided that effective production would be reduced on December 15 to 105 per cent. of standard tonnages, prices of copper rallied, but there has since been a falling away in quotations. Business has continued on the quiet side, due to a large extent to the political difficulties in connection with various territorial claims by Italy and Germany. The American Copper Institute reports that world stocks of refined copper in November amounted to 425,000 short tons, showing no change on the month. The apparent world consumption was 178,000 tons, while the world output by mines and smelters amounted to 199,000 tons. World production of refined copper totalled 178,000 tons during the month.

Metal Exchange quotations were as follow:—

Cash.—Thursday, £43 2s. 6d. to £43 5s.; Friday, £42 17s. 6d. to £42 18s. 9d.; Monday, £43 1s. 3d. to £43 2s. 6d.; Tuesday, £43 to £43 1s. 3d.; Wednesday, £43 to £43 1s. 3d.

Three Months.—Thursday, £43 7s. 6d. to £43 10s.; Friday, £43 2s. 6d. to £43 3s. 9d.; Monday, £43 6s. 3d. to £43 7s. 6d.; Tuesday, £43 5s. to £43 6s. 3d.; Wednesday, £43 5s. to £43 6s. 3d.

Tin.—Apart from a slightly better tone, the tin market has not shown any improvement during the past week, and trade continues to be dull. Consumers are unwilling to alter their present policy of buying only their immediate requirements. The European situation is not conducive to any early change in the position.

Official quotations were as follow:—

Cash.—Thursday, £214 5s. to £214 10s.; Friday, £213 7s. 6d. to £213 10s.; Monday, £213 17s. 6d. to £214 2s. 6d.; Tuesday, £214 5s. to £214 7s. 6d.; Wednesday, £214 to £214 5s.

Three Months.—Thursday, £215 to £215 5s.; Friday, £214 5s. to £214 10s.; Monday, £214 15s. to £215; Tuesday, £215 5s. to £215 7s. 6d.; Wednesday, £215 to £215 5s.

Spelter.—Business in this metal has again been very quiet, and consumers are showing little or no interest in forward contracts. The low rate of activity in the building industry must be held responsible to some extent for the slack conditions, as about one-third of the total consumption of spelter is used in building in the form of brass, galvanised material, and lithopone. From the United States the American Zinc Institute reports that many zinc producers are finding it impossible to operate in face of price cuts and threats of further reductions. Several mines and smelters are considering immediate closure. This situation is attributed to the Canadian trade agreement and the Institute has filed a protest with the U.S. State Department.

Daily market prices:—

Ordinary.—Thursday, £13 7s. 6d.; Friday, £13 7s. 6d.; Monday, £13 12s. 6d.; Tuesday, £13 11s. 3d.; Wednesday, £13 12s. 6d.

Lead.—Owing to the general quietness of trade and the close proximity of the annual stocktaking period, consumers are not inclined to make purchases of any size, and the turnover of late has been on the small side. The American Bureau of Metal Statistics reports that the world production of lead during the month of October was 155,700 short tons, as compared with 149,100 tons in September.

Day-to-day quotations:—

Soft Foreign (Prompt).—Thursday, £14 18s. 9d.; Friday, £14 16s. 3d.; Monday, £14 17s. 6d.; Tuesday, £14 13s. 9d.; Wednesday, £14 12s. 6d.

Scrap.—Another quiet week has been experienced in the non-ferrous scrap market, and only a small amount of business has been transacted.

Approximate selling prices for old metal:—New aluminium cuttings, £70; rolled, £54; cast, £30 to £32; foil, £80. Copper, £39 to £43; braziery, £35. Brass (clean), £20 to £23. Zinc, £10. Lead, £14 10s. Gunmetal, £38.

MR. J. HEPBURN has been appointed commercial manager of Davidson & Company, Limited, of Sirocco Works, Belfast. Mr. Hepburn is a native of Motherwell and commenced his business career with Hurst, Nelson & Company, Limited He was with the Clyde Crane & Engineering Company, Limited, Mossend, for some time, and is at present a director and secretary of the J. P. Tubular Heater Company, Limited, Newarthill.

MAGNETIC SEPARATORS
for the Foundry
•
"RAPID-BIAFLUX"
(Patent)
PULLEYS & DRUMS
•
The Popular "OVERBAND"
LISTED IN 5 SIZES
•
LIFTING MAGNETS FOR PIG IRON & SCRAP
THE RAPID MAGNETTING MACHINE CO. LTD.
MAGNET WORKS, LOMBARD ST.
BIRMINGHAM, 12